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S·A·E JOURNAL

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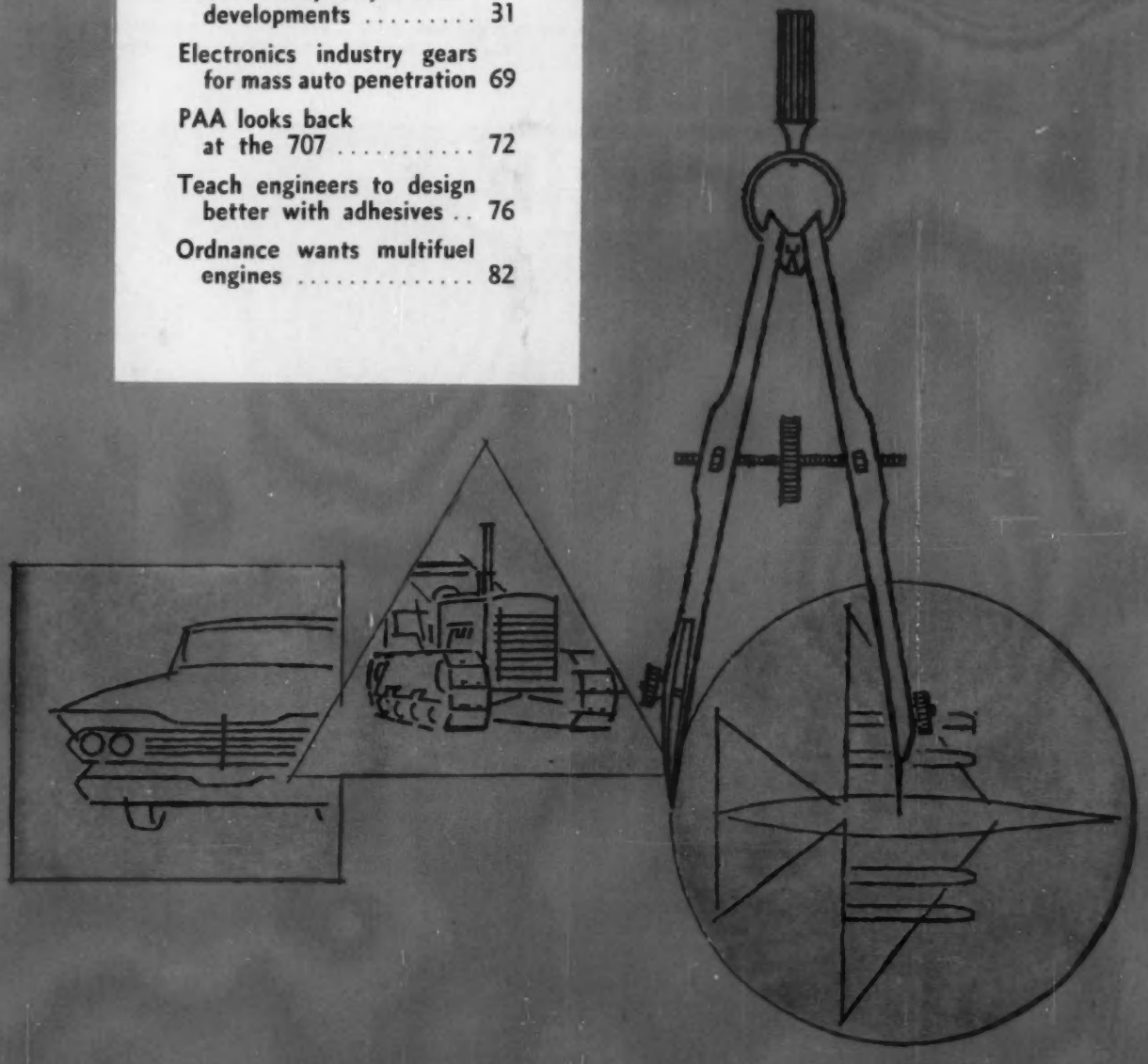

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John Deere turns to sleeve and deck construction for its new line of small engines for tractors and implements. Principle allows for larger engine in given dimensional envelope and has production advantages. (Paper No. 395A) — **Willard H. Nordenson and Russell Candee**

New power steering features increased flexibility . . . 41

The full-power power steering system developed by John Deere for its 3000 and 4000 series tractors allows the steering wheel to be mounted in different positions, without change in the subassemblies. (Paper No. 400B) — **E. H. Fletcher**

Versatile suspension for military crawler tractor 48

System provides control of vehicle height and tilt with suspension in unsprung condition, in addition to usual features. (Paper No. 399B) — **R. K. Reynolds and E. Mayer**

Tractor transmission with on-the-go shifts 55

The MF-65 "Multipower" transmission developed by Massey-Ferguson for farm tractors was designed to have a continuous power flow through the drive train, plus a smooth shift at all loads and speeds. (Paper No. 391A) — **L. E. Elfes**

Oliver's new "1800" tractor engine 62

Oliver's new 1800 gasoline engine is the result of applying to their basic Super 88 gasoline engine the concepts developed on the XO-121 engine — a 12/1 compression ratio experimental engine, which gave exceptional performance and fuel economy. (Paper No. 395B) — **T. H. Morrell and K. S. Minard**

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Driverless vehicles, collision-proof highways, glove-compartment telephones are all forecast for the 1970's. (Paper No. 390A) — **Arthur J. Runft**

PAA looks back at the 707 72

Nearly 3 years of operation have shown that jet aircraft promise to achieve standards of mechanical and operational reliability better than anything approached by piston aircraft. Here are some of the experiences of the men who fly them. (Paper No. S309) — **R. W. Blake**

Underwater ramjets may drive subs faster 74

Future submarines may be propelled by underwater ramjet systems similar to the aerodynamic ramjet. Such a system is being studied in the hope of developing faster underwater vehicles than conventional propeller systems. — **D. S. Hacker and P. Lieberman**

Teach engineers to design better with adhesives 76

The rapid advances in adhesive technology are resulting in materials that have been proved; their use now depends, in part, upon providing the design engineer with a basic understanding of the capabilities of adhesives. Adhesive Bonding Training Programs pay dividends in reduced costs, fewer production worries, and improved quality. — **James E. Austin and Lloyd C. Jackson**

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Diesel can be converted to provide fuel economy and omniverous capacity demanded by logistics. (Paper No. S303) — **James C. Emanuel**

New brake rating test guides brake choice 85

A brake rating test procedure and a formula relating brake rating to vehicle gross weight has been developed by a joint brake committee of the AMA-TTMA (Automobile Manufacturers Association-Truck Trailer Manufacturers Association). The test objective is to determine the number of brake snubs which can be made in a specified period of time, while maintaining specified deceleration and stopping distance requirements. With a maximum number of snubs established, the horsepower rating can be established. (Paper No. 364B) — **D. Paul Fisher**

Subs may swim like fish 88

Fish may show the Navy how to solve the propulsion-machinery-system noise problem in underwater craft. By studying the various aspects of sea-animal locomotion it is hoped that ways to radically improve noise characteristics will emerge. New approaches such as this probably hold the only hope of meeting the Navy's needs, as marginal improvements are all that can be expected in the intrinsically limited existing systems. (Paper No. S307) — **John H. Harrison**

Miniaturized fluid controls make moving parts passe ... 91

Miniaturized fluid control subsystems are being built from digital and logic components having no moving mechanical parts. New design and production techniques will provide these components and systems for research and development programs in pure fluid systems. — **Dr. R. E. Bowles**

Sophisticated fabrication methods build B-70's 94

Unusual, new fabricating techniques are being used on the Air Force 2000-mph B-70 Valkyrie. Among these are: sciaky boom and "burn-through" welding, brazed sleeve couplings, and "skate" machining. (Paper No. S308) — **Latham Pollock**

Distortion improves thrust washer performance 98

Advocates of super-flat washers for automatic transmissions might do well to review flatness specifications in the light of recent test results. The poorest washer performance was offered by the ground and lapped specimens. The performance of every set of purposely distorted washers was superior to the control set. (Paper No. 359E) — **William A. Weinkamer**

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New test fixture measures wet friction characteristics of materials used in automatic transmissions. (Paper No. 363A) — **G. R. Smith, V. J. Jandasek, S. R. Sprague, and R. B. Singer**

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New statistical techniques are being used to help solve spec-writing problems by the recently created SAE Refractory Materials Committee. The new techniques are being applied to a wide range of new materials for which SAE Aerospace Materials Specifications are being written. — **W. C. Schulte and D. K. Hanink**

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This is the second digest-listing of new and revised SAE reports to appear as a monthly service to SAE Journal readers. It consists of the 74 aerospace reports approved since January, 1961.

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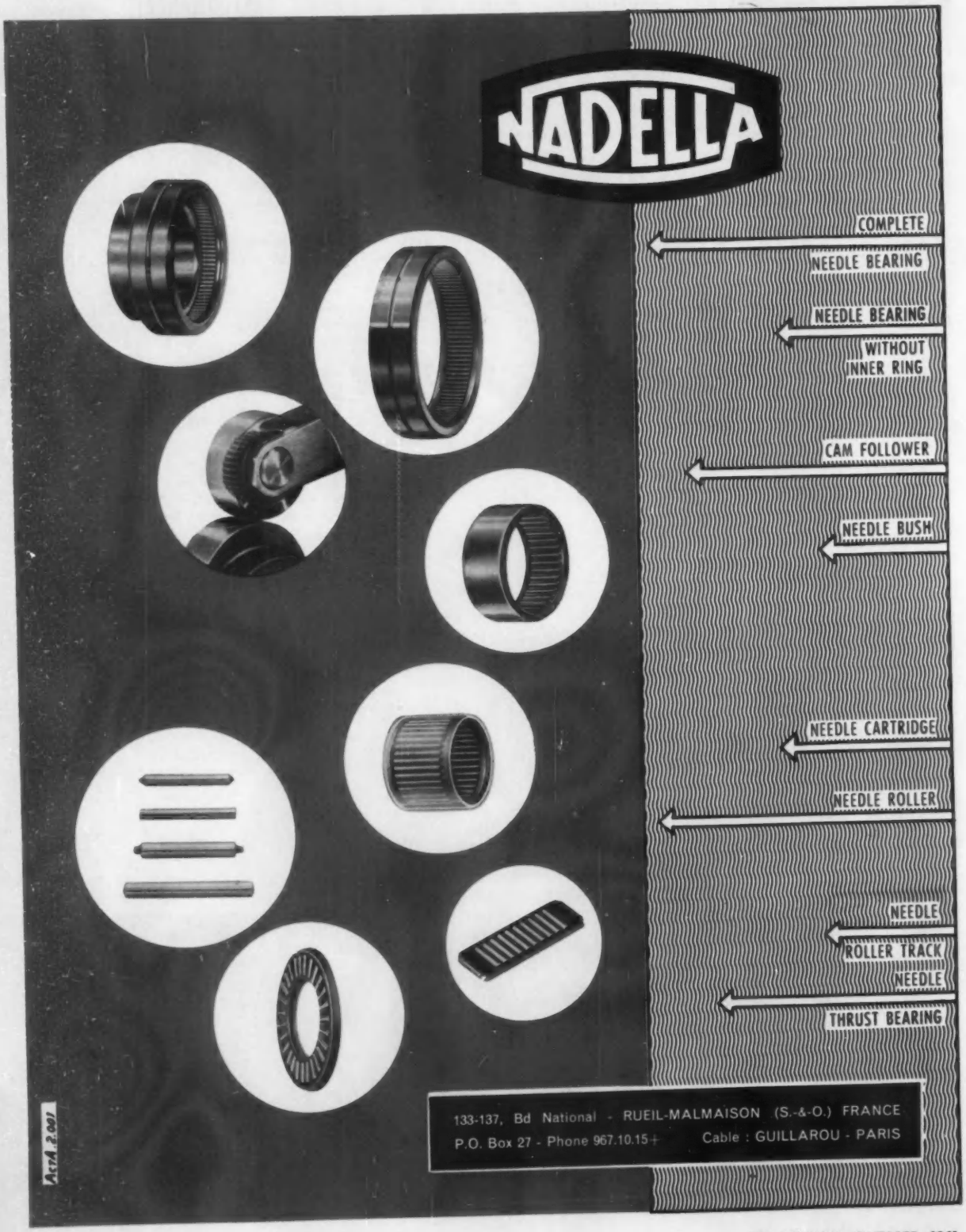
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GROUND VEHICLES AND MARINE

Radioactive Rings Solve Wear Problems in Diesel Locomotives, P. L. PINOTTI, P. V. GARIN, D. R. JONES. Paper No. 362A. Objective of research to determine factors causing engine wear in locomotives, undertaken by Southern Pacific Co. and Standard Oil Co. of California, was to reduce maintenance costs by optimum selection of engine operating conditions, piston ring and cylinder liner metallurgy, fuels, lubricating oils, and engine air filtration system; data obtained and application of findings to Southern Pacific's fleet of residual fuel-burning locomotives.

Effect of Engine Design Variables Upon Compression Ring Wear as Determined by Radioactive Tracer Technique, J. J. MARTIN, H. A. WILLIAMS. Paper No. 362B. In test program conducted by Denver and Rio Grande Western Railroad, Standard Oil Co. California and General Motors, effect of several engine design variables upon piston ring wear in GM Model 16–567C diesel engine was measured; tests involved unit fuel injectors, compression rings, oil control rings, and combinations of above; high quality distillate fuel and mid-continent crude oil was used.

Effect of Exhaust Pipe System Upon Performance Characteristics of Two-Cycle Diesel Engine, I. WATANABE, T. NAKAUA, T. ANDO. Paper No. 367B. Effect upon engine performance of exhaust pipes having diffusers, nozzles, or bends was examined employing same engine; details of experimental set and method of experiment at Keio Univ., Japan; influence of exhaust pipe lengths; experimental results and considerations.

Center Point Steering Axles, K. M. KOCH. Paper No. 368B. Historical review of design and development of center point steering type front axle; general principles of center point design and performance; study of static, rolling, and stability steering effort; it is shown that center point principle is justified by its ability to substantially reduce driver effort.

Some Experiences With Ground Effect Devices, C. A. AMANN, J. W. SCHEEL. Paper No. 370B. Fundamentals of air bearing, plenum chamber and annular jet; study carried out at General Motors Corp. to construct man carrying test vehicle; fan design and model tests; results secured with models having 5-hp and 15-hp engines of integral propulsion system, and 15 hp fan engines, separate propulsion system; vehicle lift and thrust; vehicle directional control; overall impressions. sions.

Piezoelectric Ignition System for Small Engines, E. CRANKSHAW, R. ARNOLD. Paper No. 375A. Background on history and operation of piezoelectric materials and development of ignition system by Cleveland Graphite Bronze Div., Clevite Corp.; features, operation and characteristics of "spark pump" using two ceramic elements developing 16,000 — 19,000 v, with energy level of about .015 joules at 18,000 v; relationship between voltage and energy for elements used is shown in curves; potentiality to automotive multi-cylinder engines.

Stratified Charge Operation of Spark Ignition Engines, L. D. CONTA, P. DURBETAKI, J. L. BASCUNANA. Paper No. 375B. History of charge stratification, and early work carried out at Univ. of Rochester using Broderson method; current research done and conversion of CRF — F4 method engine to stratified operation; new test procedure evolved and performance data obtained; summary of results of research program using 4 different engines having radically different combustion chamber arrangements.

Corvette Story, P. J. PASSON. Paper No. 377A. Summary of engineering concepts incorporated into 1961 car; reference made to 3-station operation in producing underbody, use of reinforced plastic reducing weight of

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Corvette body by 300 lb, and sequence of assembly operations; there are 9 inspection stations along line, 2 of which are of particular interest; chassis roll and water test operation; engineering features of car.

Postwar Diesel Installations in U.S. Navy, R. W. CROWLEY. Paper No. 378A. Navy has 6,000,000 diesel-hp installed in active ships, including 8400 installations in ships and boats since World War II; examples of new installations: diesel generator units for new SS563 class submarines; application of nonmagnetic diesel to minesweeping craft; Curtiss Wright 12V-142 diesel for various uses and diesel plant of new submarine tender AS31; diesel machinery in LST 1173 class ship and CODAG machinery for 35,000-hp destroyer escort.

Power for Pushing, C. R. HORTON, Jr. Paper No. 378B. Towboat power plant consists of diesel engines of total power ranging from 1000 to 9000 hp, driving propellers, at speeds of 300 to 150 rpm; majority use reverse-reduction gearing; criteria for judging desirability of prime mover differ for river towboat than for other marine applications; drive problems of river towboats, characteristics of which seem to be supplied best by modern reverse-reduction gear units.

Engine Air Flow Measurements with Laminar Flow Elements, G. H. MILLAR, E. GILLIG, A. HEJDUK. Paper No. 379C. Paper shows that capillary flow air flow meter, when properly designed and applied, is most versatile engine air flow measurement equipment available within range of accuracy required to obtain greater knowledge of engine performance in as-installed conditions in vehicles; extension of air flow metering techniques to study of performance of engines used in outboard motors, chain saws, and target drones is shown.

Method of Measuring Instantaneous Friction of Piston Rings in Firing Engine, A. R. ROGOWSKI. Paper No. 379F. Details of cylinder, adaptable to CFR engine crankcase, built by Sloan Automotive Laboratories at MIT, to measure instantaneous value of friction force existing between piston rings and cylinder wall under normal firing conditions; as apparatus has never been described in engineering journals, its possibilities as research tool may have been overlooked; results obtained with apparatus when used on short projects, limited operating conditions, ring and cylinder materials.

Consideration of High Temperature Thermodynamics of Internal Combustion Engines, C. W. VICKLAND, F. M. STRANGE, R. A. BELL, E. S. STARKMAN. Paper No. 380A. Reference to charts of R. L. Hershey, J. E. Eberhardt and H. C. Hottel which authors aim to extend to as high temperature as available thermochemical data would allow; progress report is limited to method and results of machine calculation of equilibrium, from previous limit of 5500 R to 7000 R; 12 equations presented whose solution describes composition of products of reaction of any C-H-O-N system. 21 refs.

Thermodynamic Measures Give Low Fuel Consumption and Favorable Torque Characteristics in Automotive Spark-Ignition Engines, E. W. HUBER. Paper No. 380B. Process of "extended expansion" and principles involved; theoretical concepts of optimum design of spark ignition, throttle controlled engine; experiments at Institut fuer Motorenbau Dr. Huber, Germany, show that application of design principles can be carried much further; compression volume can be made smaller, intake duration reduced at expense of reduced charge weights at high rpm; result is large increase in torque availability at low rpm without knock.

Influence of Compression Ratio and Dissociation on Ideal Otto Cycle Engine Thermal Efficiency, M. H. EDSON. Paper No. 380C. Paper examines influence of compression ratio and association over extreme range of compression ratios, i.e. from 4 to 300, to see theoretically if chemical dissociation can limit Otto cycle engine thermal efficiency; tabulation of coefficients used for calculations; it is concluded that there is no upper limit to which compression ratio of Otto cycle engine can be raised.

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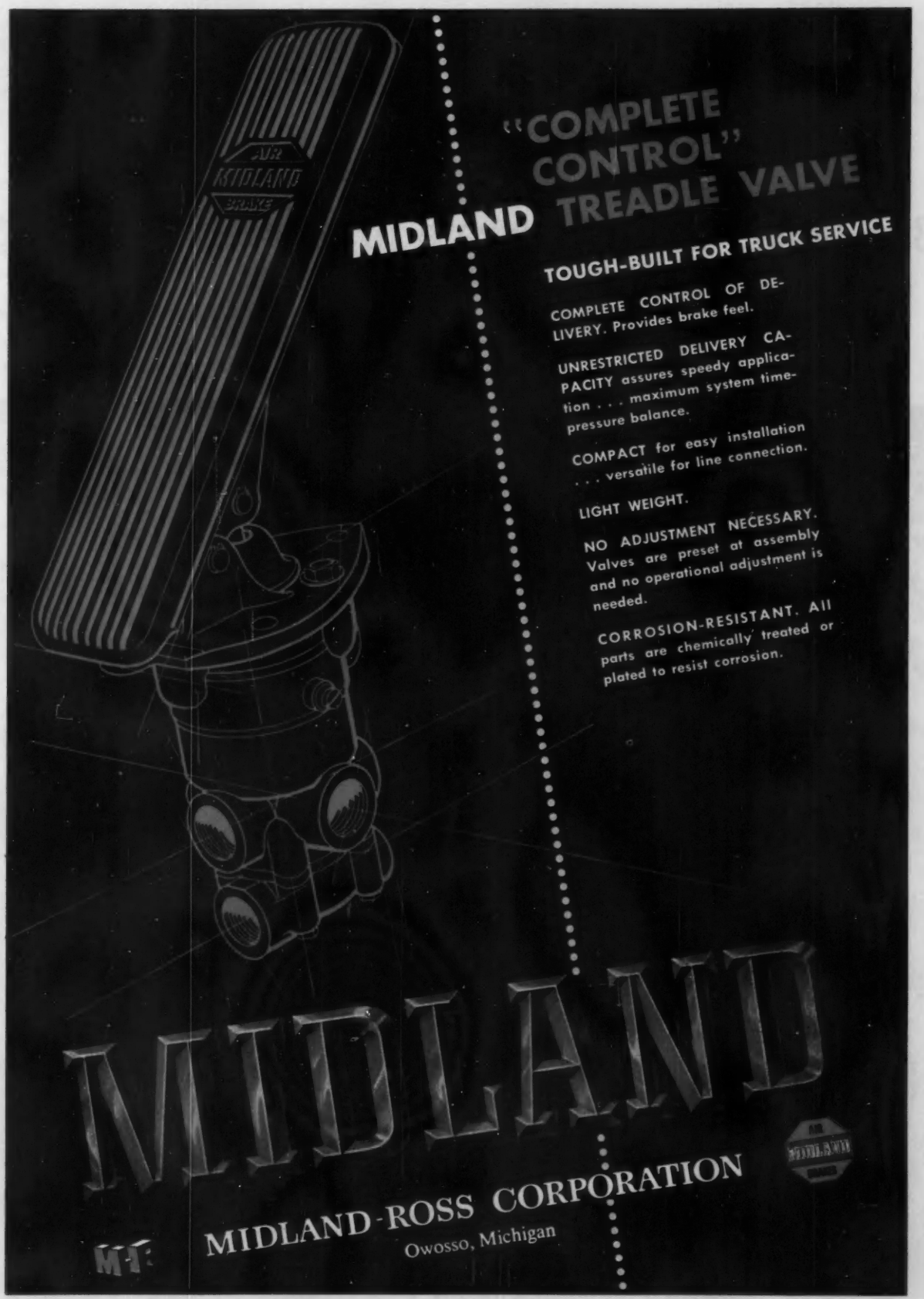
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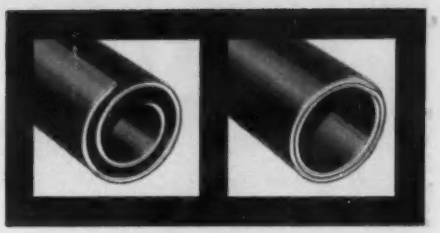

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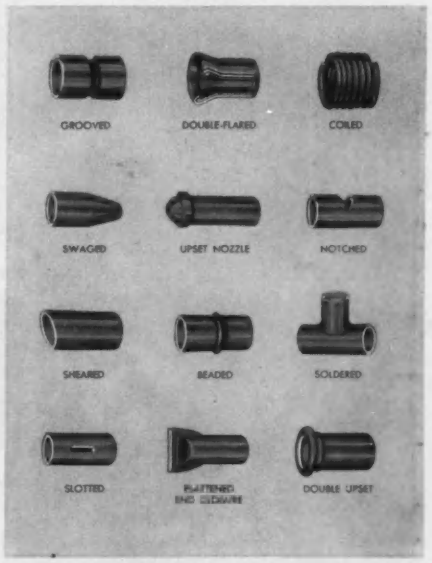

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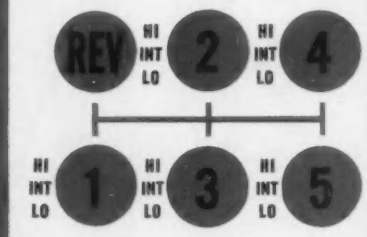

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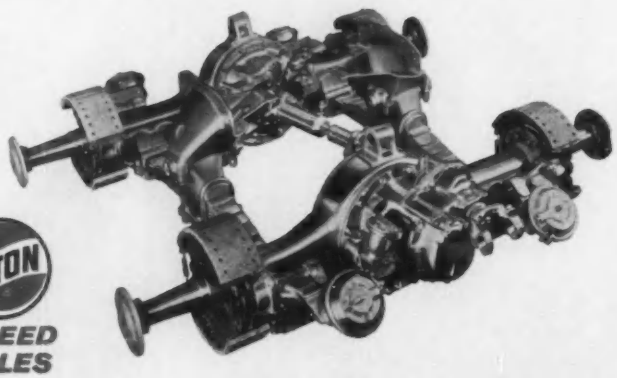

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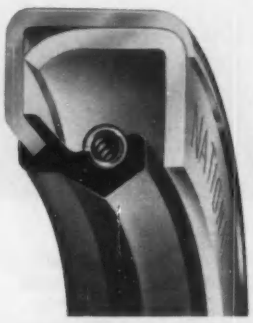

National 450,000

The bonded design was pioneered at National Seal—industry's oil seal headquarters for 40 years. If yours is a standard application, your National Seal field engineer has the proper BUD seal for prompt delivery; if yours is a special design his experience can help you cut sealing costs. He's listed in the Yellow Pages, under "Oil Seals."

National 480,000

New 20-page National Catalog 61-B lists BUD seals available now. Write for your copy today.

NATIONAL SEAL

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General Offices: Redwood City, California
Plants: Van Wert, Ohio; Downey and Redwood City, California

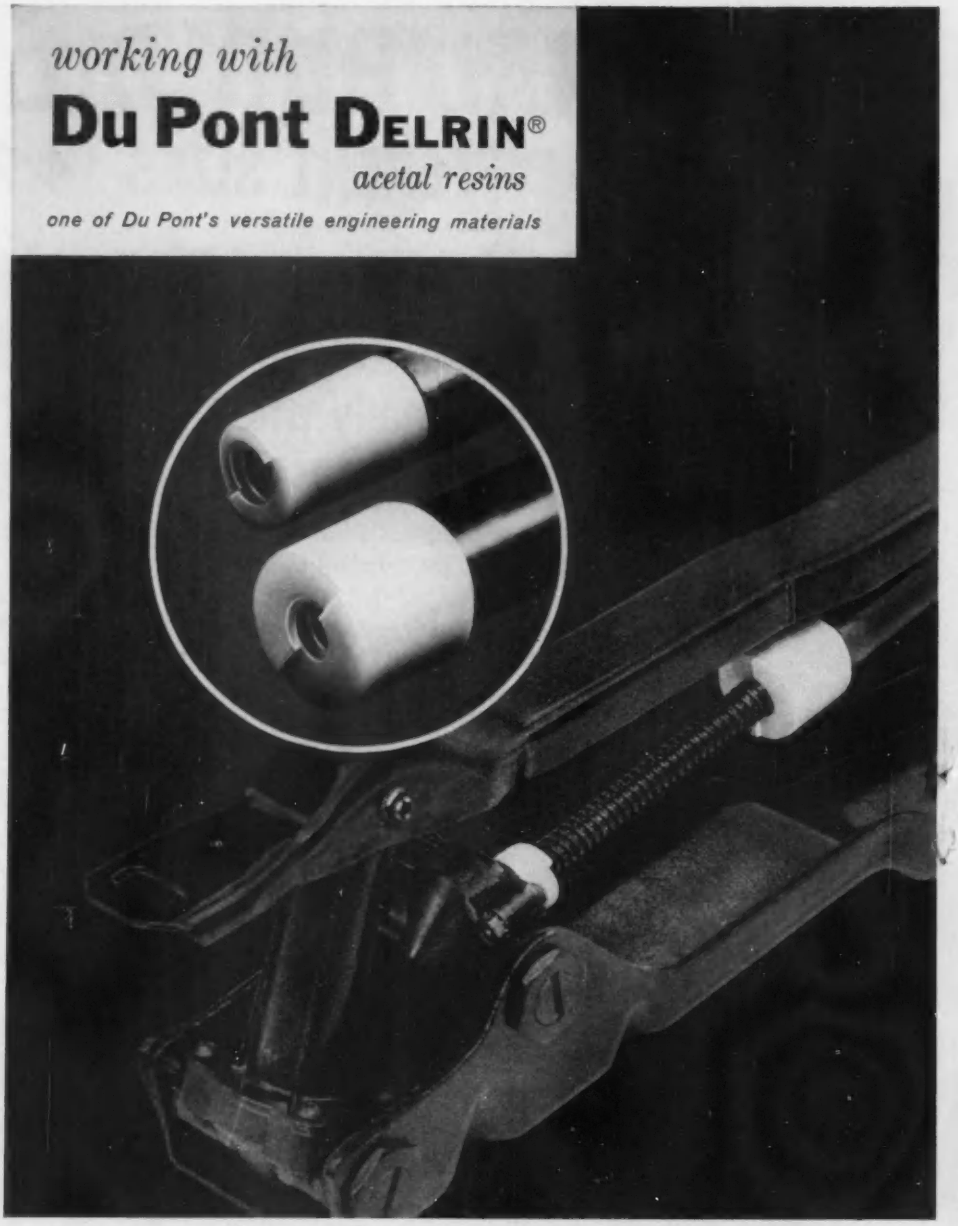
*BUD (Bonded Universal Design)

working with

Du Pont DELRIN®

acetal resins

one of Du Pont's versatile engineering materials

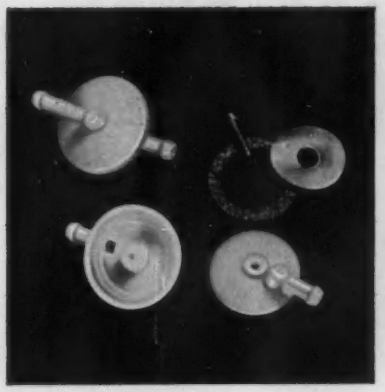


Now parts of DELRIN® cut costs and improve operation of new power seats

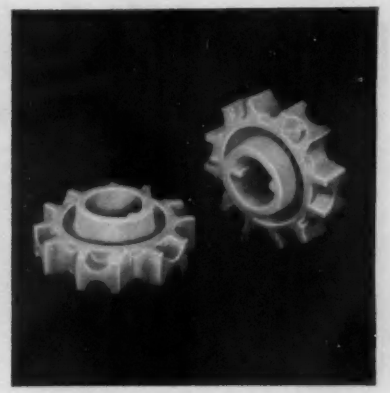
Shown above is part of a new six-way power-seat adjusting mechanism used in a luxury automobile. To move the seat, power-driven screws turn inside nuts (shown in circle and at upper end of screw) molded of Du Pont DELRIN acetal resin. The nuts are attached to seat members, causing the seat to move up or down, forward or back. The high strength of DELRIN, its low coefficient of friction, and its dimensional stability under varying conditions of temperature and humidity assure smooth, accurate and quiet operation. Economical injection molding of the nut in DELRIN results in a substantial cost reduction as against fabrication of the part in steel.

In the complete mechanism, transmission gears and electrical coil bobbins are molded of tough Du Pont ZYTEL® nylon resins, and liners (tubing) of Du Pont ALATHON® polyethylene resin are used to eliminate metal-to-metal noises. Stop nuts (at lower end of screw) are also molded of ZYTEL.

Design and manufacture of the completed unit are by Ferro Stamping Company, Detroit, Michigan. Nuts of DELRIN molded by Sun Plastics, Inc., Cayuhoga, Ohio, and Molmec, Inc., Walled Lake, Mich.; gears by W-L Molding Co., Kalamazoo, Mich.; tubing of ALATHON by Lus-Trus Corp., Ypsilanti, Mich.; and stop nuts of ZYTEL by Molmec, Inc.



This simple but efficient fuel filter for small gasoline engines is made with filter and gasket seated in a tough, stiff part of DELRIN and a cover of ZYTEL which flexes and seats firmly on the gasket. The use of these Du Pont engineering materials eliminates finishing operations, provides lower assembly and shipping costs. (By Hoffman Industries, Spring Arbor, Mich., for Tillotson Mfg. Co., Toledo, O.)



Key unit of a new corn planter is this sprocket, molded of DELRIN, which slides along a grooved shaft. Cast iron formerly used tended to stick, corrode and erode. The natural lubricity and corrosion and abrasion resistance of DELRIN provide longer life for the sprockets . . . lower finished-part cost. (Molded by Rockford Molded Products, Rockford, Ill., for John Deere Planter Works, Moline, Ill.)

DELRIN® makes possible improved design in increasing variety of auto components

In automotive design applications ranging from door handles to instrument housings, from lamp sockets to lubrication-system components, the unique combination of important engineering properties of DELRIN acetal resin is being put to good use. DELRIN offers designers a material with high fatigue-endurance limit, high stiffness, high strength, good resistance to creep, good toughness and good resilience—all over a wide range of temperatures and environments. It has good abrasion resistance, excellent resistance to solvents and oils, good frictional properties. And it offers the economies of injection molding plus the virtual elimination of costly finishing operations. For more information about Du Pont DELRIN acetal resin that will help you evaluate this remarkable new engineering material for *your* applications, mail the coupon below.

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"Pass the Oil Can, Orville"

Aviation progress—from the faltering flight at Kitty Hawk to the latest continental jet hop—has depended in large part on the fuels and lubricants that bring planes to life.

The 12 horsepower engine that flew Orville and Wilbur Wright into history was no more demanding than a Model-T's motor. But today's more discriminating jet turbines need fuel that tests purer than the milk we drink and lubes that won't fail in the numbing upper air. The years between have been bridged by millions invested in oil laboratories and refineries.

Sinclair Refining Company is proud of its role in aviation progress that dates back to the World War I "Jennies." Today, that company is a major supplier of jet fuel to airlines and the armed forces. *It supplies over 40 per cent of the lubricants used by all major scheduled airlines in the U.S.*

Passing the oil can in the competitive aviation markets calls for resourcefulness in research and manufacturing skill. *Where confidence counts with customers, Sinclair flies high.*

SAE—Sinclair salutes the Society of Automotive Engineers for stimulating the research and the exchange of technical data which has brought constant improvement in self-propelled vehicles, their engines and related products. Through its 25,000 members, the SAE keeps Americans moving safer and faster on land, air and sea. Organized in 1905, it is one of the largest engineering societies in the world.

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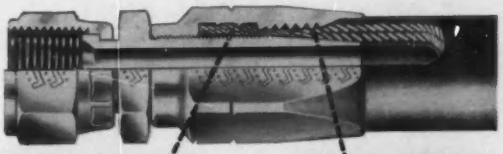
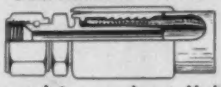
STRATOFLEX "SCREW-TOGETHER" TYPE



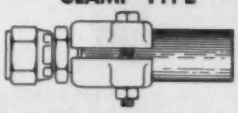
- Minimum envelope dimension
- No special tools required for assembly or disassembly
- Uses standard hose
- Complete reusability
- Pressure rating equal to burst of hose
- Uniform compression
- Long life proven in service

SLEEVE AND SEGMENTED TYPE



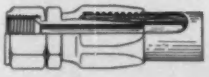
Wire exposed to corrosion • Limited reusability of segments • Large envelope dimension • Special tools and/or equipment required for assembly and disassembly • Non-uniform compression • Limited service history

CLAMP TYPE



Doesn't grip wire • Limited pressure rating • Large envelope dimension • Non-uniform compression • End of hose exposed to corrosion

NON-SKIVE TYPE



High assembly torques • Inconsistent grip of wire • Uses non-standard thin covered hose which has critical tolerances • Special tools required for proper assembly of hose to socket

SF5-1

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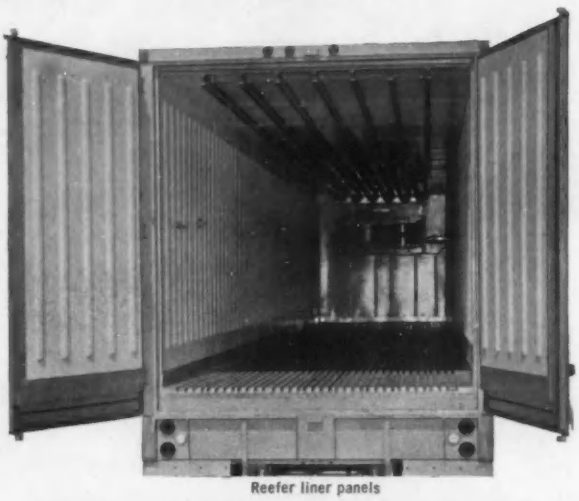
If transportation is your business, (MFG) belongs in your plans — for economy, strength and material superiority. Tell us your problem and we'll help solve it; or send coupon for free descriptive literature.

Complete White truck cab



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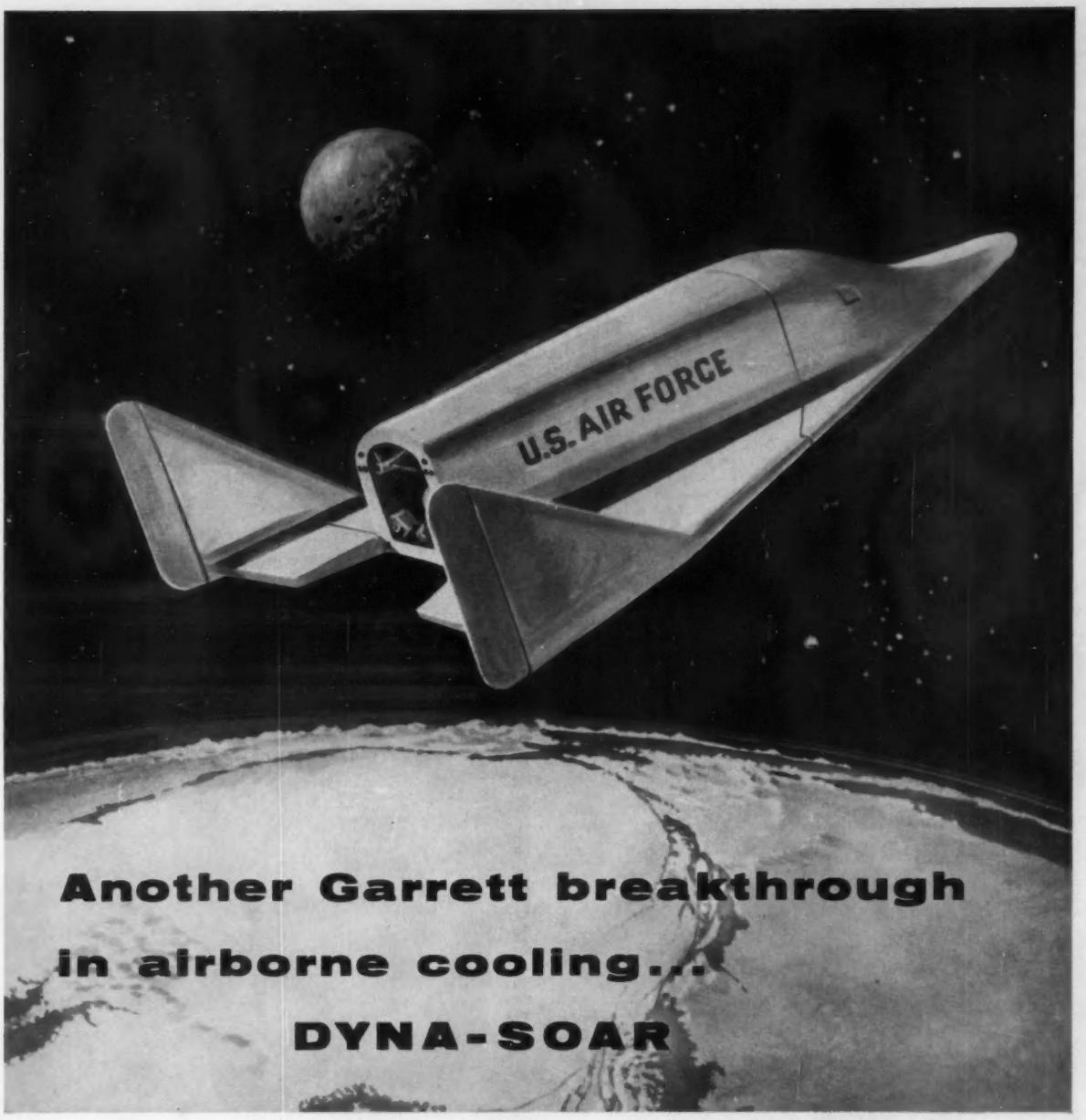

Boeing Dyna-Soar Manned Space Glider

Garrett is now developing Dyna-Soar's thermal control system—again demonstrating its 20-year leadership in the pioneering of airborne cooling methods by its AiResearch Manufacturing Divisions.

An important contribution to the rapid over-all development of the Boeing Dyna-Soar manned space glider, the compact, lightweight system will cool the pilot and his equipment, economically utilizing the cryogenic hydrogen fuel of the accessory power system.

The development of this hydrogen system exemplifies Garrett's continuing advancements in airborne cooling, including air cycle and Freon refrigeration systems, zero gravity gas and liquid systems, and new developments in space radiators and other systems using exotic liquids and metals...all leading to the development of more advanced thermal control techniques for spacecraft.

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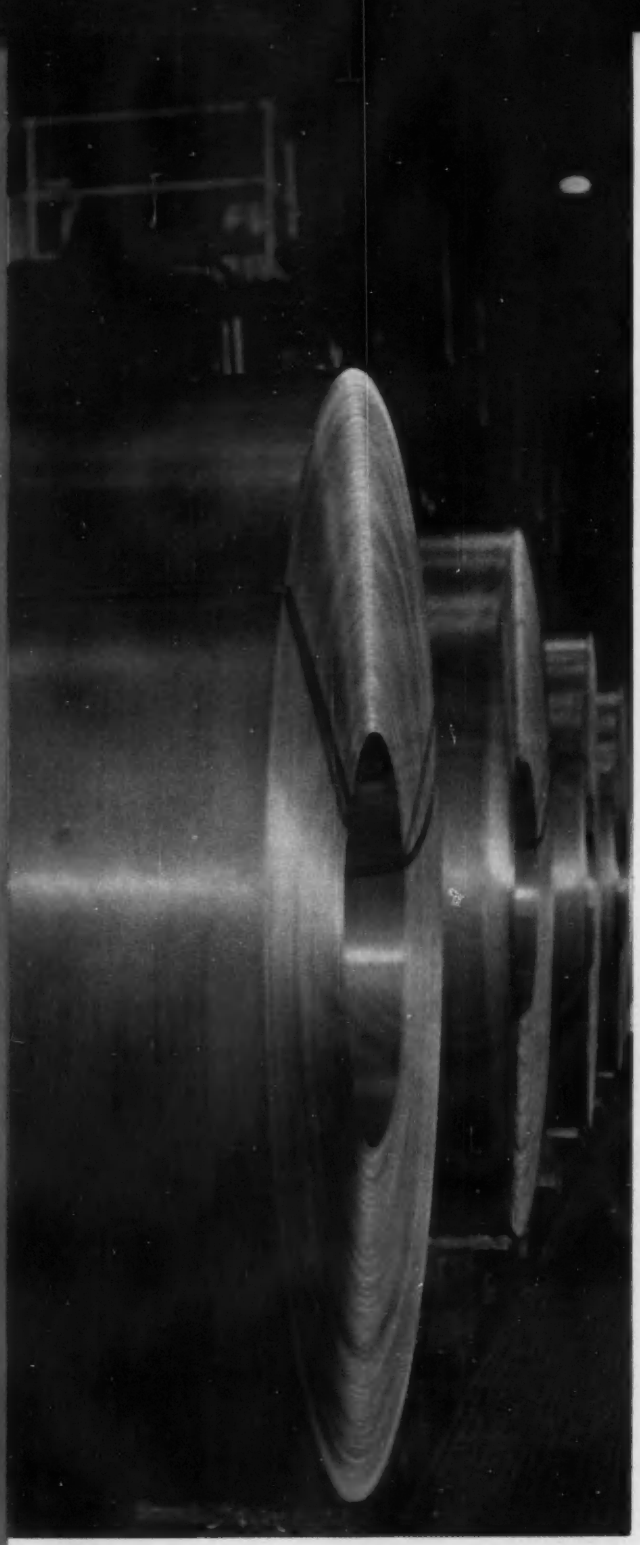

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You get larger coils, higher quality from Youngstown's big, new 79" hot strip mill

Higher quality hot rolled steel sheet in larger coils. That's what you get from our expanded and modernized 79" hot strip mill in Campbell, Ohio. To bring you improved hot rolled sheet and strip, more than $60,000,000 was invested. Probing television monitors and delicate, sensitive electronic devices plus massive roll stands, and bigger coilers combine to bring you even better quality control.

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Get steel stamped with the mark of Youngstown. Get longer, stronger, flatter steel. Steel sheet and strip of more uniform quality. With better physical properties. Hot and cold rolled steel that is easier to work with and more economical to use because you can get larger coil sizes to 38,000 pounds. In 24" to 72" widths. Order to your specifications. Get fast, reliable delivery from your Steel Service Center or through the 28 Youngstown Offices.

Youngstown – growing force in steel

For full details on Youngstown steel sheet and strip, write: Dept. 11-A,
The Youngstown Sheet and Tube Company, Youngstown, Ohio

Some Ideas

for your file of practical information on drafting and reproduction

KEUFFEL & ESSER CO.

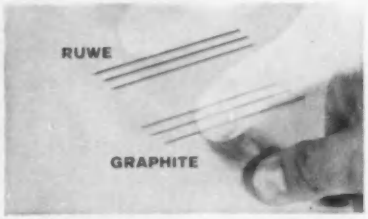
The stone tablet and chisel were pretty widely used writing and drawing instruments in their day.

But they don't command much of a following any longer. Like so many tools of the past, they gave way to better methods of portraying information. Some of these methods occurred by accident, some were developed by experts to serve specialized needs. Three good examples of the latter are described here.

A Couple of "Better" Pencils

When polyester drafting film first came into use, it was found that standard graphite pencils with clay binders, while fine for paper, smudged too readily on film.

So a new kind of pencil was needed—and developed. It was called the Duralar. With both binder and color agent made entirely of plastic, Duralar deposited a black, dense line on film, which could neither be smudged nor washed away.



But since washability is not the touchstone of every drafting operation, K&E went a step further. Result – the Ruwe pencil. Having all the "fine feel" and erasibility of graphite, on both film and cloth, the Ruwe deposits a blacker, denser line than graphite, with the smudge resistance the old graphite pencil could not provide.

Here's why: the Ruwe pencil *is* graphite, but with a plastic binder instead of clay. Color coded in five degrees of hardness from 2S to 6S, Ruwe is available in wood pencils and leads. More good news is that Ruwe is now available in 2S and 3S hardnesses for fine-line automatic pencils as well. The lead is just .036" in thickness – ideal for free-hand lettering.

It's interesting to note, that since the introduction of Ruwe, other plastic-graphite pencils have been placed on the market. If you're interested in testing the original we'll send free Ruwe pencils to you – just send the coupon.

Now You See 'em...Now You Don't

For engineering drawings, or freehand sketches, K&E GUIDE LINE[T.M.] tracing papers, cloths and films make light work for you – by making light *work* for you. The light blue cross-section lines are visible to the eye, but will not reproduce on your diazos or blueprints. Other companies make similar products but here's the important K&E contribution: GUIDE LINE is now available in the widest variety of drafting media ever. Specifically: ALBANENE® and CRYSTALENE® 100% rag stock tracing papers, PHOENIX® water-resistant tracing cloth and HERCULENE® polyester base drafting film. So whichever sheet you use, odds are it's available in GUIDE LINE first.

We especially recommend GUIDE LINE products for accurately guiding freehand work such as plant layouts, organization charts, electrical diagrams, etc. Your freehand work actually will look more like a finished detail than a sketch. And confidential notes will drop out too, if written or typed in special colors.

Available in a wide variety of grid sizes, GUIDE LINE comes in rolls or pads on ALBANENE and CRYSTALENE, in rolls on PHOENIX and HERCULENE, and can be supplied with your own title block or special heading.

Send for some free samples and the GUIDE LINE brochure.

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No more "Alice in Wonderland" wandering about when you want to locate the graph sheet you need for a specific job. Reason – K&E graph sheets now are packaged with a new "looking glass" – A time-saving *visual* package. This unique package has a window in the front so you can see the sheet inside. This is a boon, especially if you use a wide variety of graph sheets. Apart from the packaging, we've done a few other things to make graph-sheet selection easy and infallible.

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12,300 variables at a glance. Here's a typical stock market chart used to study relative market action. Center line is market behavior of 540 stocks over 20-year period. Two basic stock groups of 25 and 50 individual stocks, averaged, are plotted against market (figured at zero per cent). Resultant chart shows all-important slope of curve which – far more than gross increases – tells the story of the stocks' vitality. No list of statistics, no matter how exhaustive, could give the relative interactions shown here. This picture is possible only with a graph.

KEUFFEL & ESSER CO., Dept. SJ-10 Hoboken, N. J.

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The answer—we did it!

The first delivery of completed castings was made in three days less than three weeks.

This is *not* a routine situation. But it is an outstanding example of how Doehler-Jarvis' 57 years of leadership in die casting can work to your benefit in all circumstances. It was the design and engineering skill and experience of Doehler-Jarvis, together with their unmatched production facilities and know-how which helped Black and Decker meet its ultra-tight production schedule.

But there was more to gain than speed. The die cast parts delivered to Black and Decker have the high strength, impact resistance and abrasion resistance needed to take rough handling; they are sound and dimensionally stable to permit and maintain close tolerance; and their attractive finish adds extra sales value.

You will find it to your advantage to talk to Doehler-Jarvis about die castings for your products. Contact the office nearest you.

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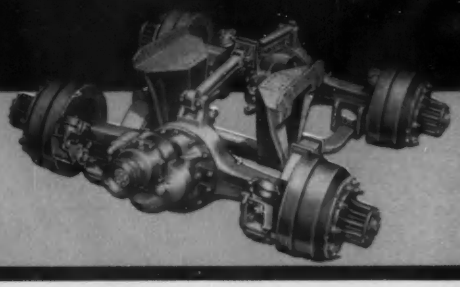
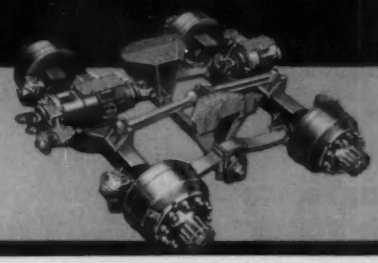
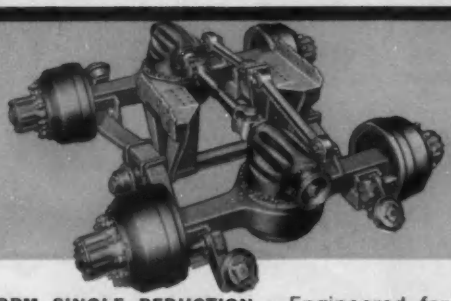
One of the four types of driving tandems below is ideally suited for your particular requirements:



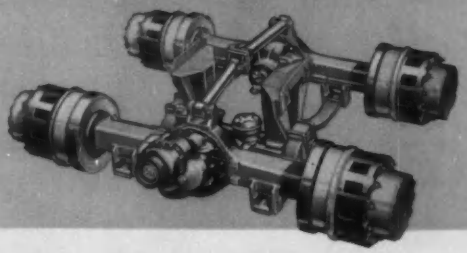
HYPOID SINGLE REDUCTION • Engineered for minimum weight and cost • Husky hypoid gearing for maximum gear strength • Axle ratios up to 8.6 to 1 • Nine models with capacities to 46,000 pounds.



HYPOID-HELICAL DOUBLE REDUCTION • Engineered for universal heavy-duty operations • Balanced hypoid-helical double reduction gearing • Wide selection of ratios • Six models with capacities up to 65,000 pounds.



WORM SINGLE REDUCTION • Engineered for simplicity of design and long life • Worm gear may be reversed to increase operating life • Four models with capacities up to 50,000 pounds.



FULL PLANETARY DOUBLE REDUCTION • Engineered for extra heavy-duty operations • Planetary reduction is at wheel end for greatest mechanical advantage • Capacities up to 150,000 pounds.

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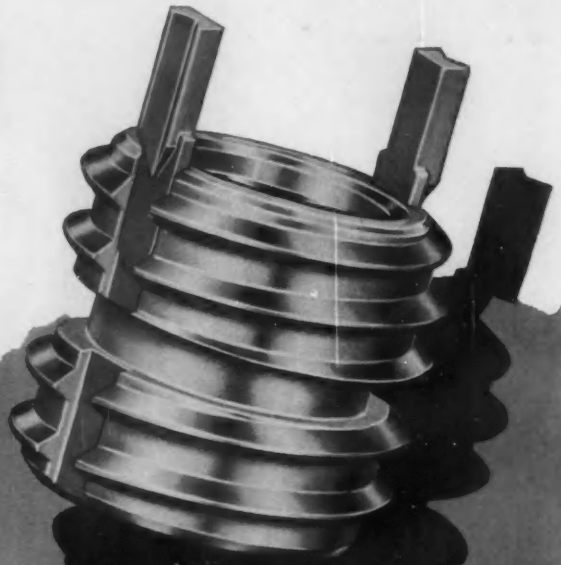

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KNHXHL
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KNB & KNBL
Blind end inserts, with and without internal thread lock

KNHB & KNHBL
Blind inserts, with and without internal thread lock

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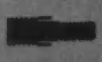

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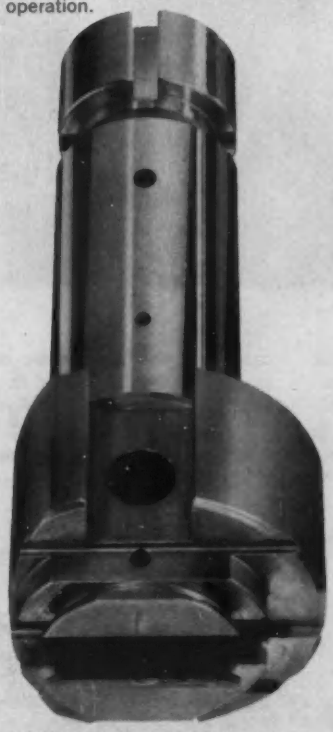

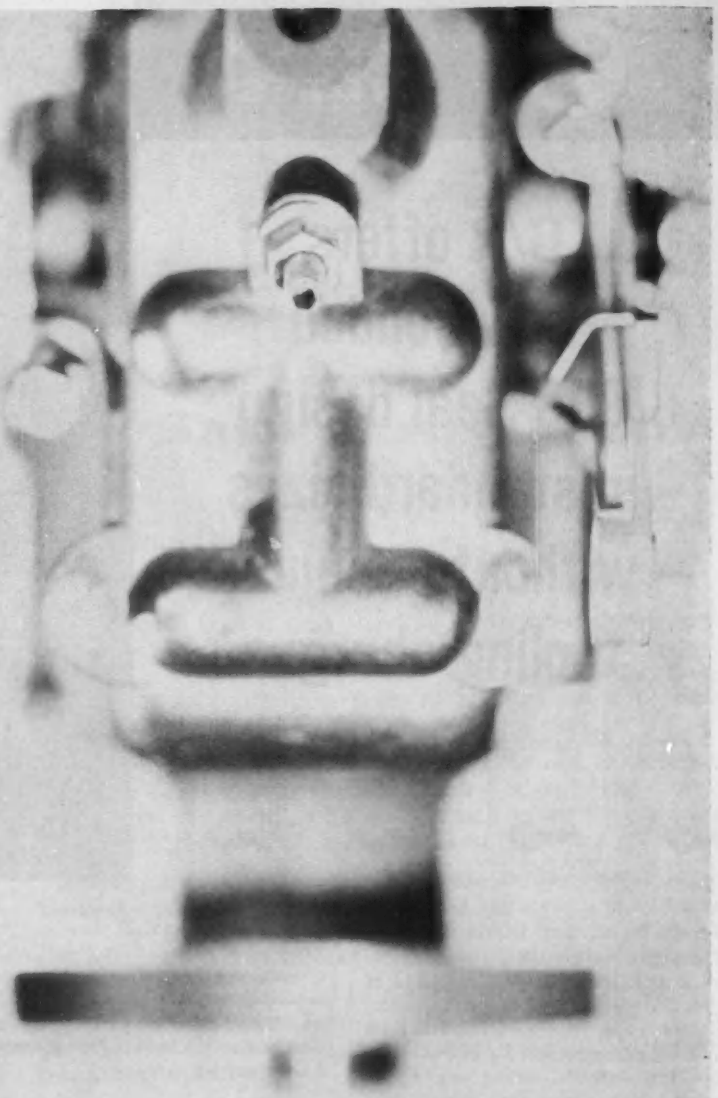

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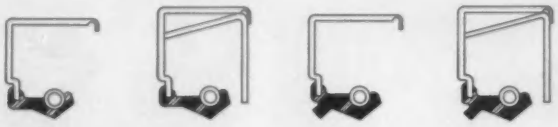
DESIGN NOTES

C/R offers new bonded CRS Seal design in standard sizes — without premium tooling charges



Design Advantages

The CRS Seal now provides a new level of C/R Seal performance through its simple, bonded design. There are no internal parts to misalign, no avenues for internal leakage. The shell and sealing member are integral — bonded securely for the long life of the seal. The CRS Seal incorporates a sealing member with both improved lip configuration and improved concentricity. The sealing member has been strengthened over former designs by placing more material at points of major flex and wear — and without increased shaft loading.

Designer Advantages

The CRS Seal gives the designer one, basic, rugged shaft seal design which may be applied with high reliability to the great majority of common shaft seal applications — particularly in industrial, automotive, farm, and off-the-road equipment.

Four basic design variations are available. As you can see, these provide an auxiliary sealing lip, where it may be required, or provide extra rugged shell construction where conditions suggest the need to protect the seal lip against assembly damage — or where large, heavy-duty shafts are being sealed.

Selection of the new C/R Type CRS Seal gives the designer and buyer major advantages over special seals: shorter lead time on orders, simpler specification, savings in time and money, and improved assembly quality and reliability.

Operating Maximums*

Shaft Speeds	3600 fpm (single lip) 2500 fpm (double lip)
Run-out	.015" TIR dynamic eccentricity .010" static eccentricity
Temperature	−30 to +275°F. (225°F. in EP lube)
Pressure	5 psi (single lip) 10 psi (double lip)
Media	Oil, grease, fuel, water

**Not all conditions present in one application*

New, Improved Compound

Standard sealing members for the C/R Type CRS Seal are molded of a new Sirvene synthetic rubber compound having markedly superior sealing and wearing properties. It is a Buna-N-based material with low-friction characteristics. The CRS Seal can also be furnished in the usual special materials such as acrylates, Silicones, and butyls. Shells are of standard steel, but can be provided in corrosion-resistant materials on special order.

Consult C/R Engineers

For assistance on the application of the new CRS — or on any oil seal problem, get in touch with C/R Oil Seal Engineers. They're specialists in fluid sealing — and will gladly cooperate with you.

For More Design Data:

You will want the complete design data on the new CRS Seal. Write for our Bulletin CRS-100. It gives you the complete list of standard sizes, widths, O.D.'s, shell thicknesses and sealing lip heights. You will want it to compare and then specify C/R's CRS Seal.

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For Sake of Argument

Creeds and Objectives . . .

SOME FOLKS keep so busy standing up for what they believe that they rarely have time to get anything done. They are strong on creed and weak on objectives. Even when they favor a project, they concentrate more on what ought to be done than on how to do it.

Too often a creed is only a pious expression of what a fellow thinks he *ought* to achieve. An objective is more likely to be a statement of something he really means to try for. A creed results in "I believe . . ."; an objective in "I shall . . ."

Most of us would get further if we wrote down objectives as frequently as we do credos; if we focused our aims as specifically as our beliefs. . . . Business associates would find us oftener a part of their solutions instead of their problems.

A creed is more likely to be fought about than striven for. The chap whose beliefs influence the selection of his aims is less likely than most to find his creed impeding movement toward his objectives.

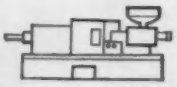
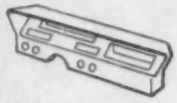
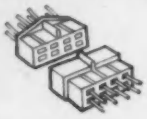
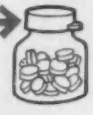
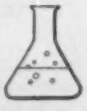
Creeds split people apart as often as they bring them together. So do objectives, when they are conflicting. But once objectives are harmoniously focused, those involved start going ahead together. Agreement about creeds is only a start. The agreers still have to figure out how to apply them to everyday life.

In business especially, group objectives are necessary to group achievement. Group beliefs aren't. On many projects, no focused group understanding exists about the principles involved. But this doesn't hinder good group achievement when all sail toward the same practical goal.

Norman G. Shidle

"Instincts In Action," a new book by Norman Shidle, includes more than 140 "For Sake of Argument" pieces selected from those printed between 1946 and 1961. . . . Published by SAE, it is now available for distribution and may be ordered by circling SP-222 on p. 6.

What's News In Plastics...

Escon® polypropylene offers molders  a balanced combination of properties for a wide range of molding applications such as high strength and impact resistance in automobile dash boards  ...excellent electrical properties for cable connectors  ... high heat distortion temperature in vaporizers ...low water pick-up in distributor caps ... outstanding dynamic fatigue resistance for "living hinge" in accelerator pedals and snap-fit closures  for containers...outstanding chemical  resistance plus high gloss, surface hardness, and quality "feel" in dinnerware . All available for volume production at low cost.

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chips

from SAE meetings, members, and committees

RATIO OF GVW TO ENGINE HP should be in the range of 300–350 lb per hp for normal off-highway end dump truck operation, suggest some truck engineers. This ratio, they say, will provide good acceleration and, with proper gearing, permit operation on grades in excess of 20%, when necessary.

For the semi-trailer type off-highway vehicle, which normally operates on level hauls and on grades up to 10%, this ratio is in the range of 400–475 lb per hp.

TAXES, TAXES EVERYWHERE . . . Although German engine designers believe in the philosophy of using a larger displacement for better economy they have shunned this approach. Since German passenger cars are taxed on a displacement basis, maximum performance must be squeezed out of a small engine.

FUEL represented 50% of all tonnage shipped overseas to fight the last two wars.

SPEEDS OF FAST SEA ANIMALS have been reported as follows:

Animal	Speed (Knots)
Swordfish	50+
Flying Fish	35
Porpoise	32
Mackerel	26
Barracuda	24+
Whale	21

The swordfish data are based on calculations of the minimum velocity required for a swordfish to penetrate with both beaks, an oak ship's hull one-foot thick and sheathed with copper.

"FLEXIBLE AUTOMATION" is the term being applied to use of automatic machines which get their instructions — not from cams — but from punched cards, punched tape, or magnetic tape. On such machines, a change in design within the capacity limits of the machine can be made by changing the tape . . . and in a matter of hours.

SOME SAY European cars are small, yet they ride and handle well. This is an opinion not necessarily shared by all American engineers. Many small cars do not provide a good ride, because their springs are stiffer and the frequency of pitch is higher, some American engineers say, adding: "Many European cars have swing axles, and in order to limit the change in camber due to load changes, stiffer springs are necessary.

"The swing axle is predominant in European design, because the smaller amount of unsprung mass allows better "adhesion" to the surface of European roads as they have been known. . . . Imported cars do not, by and large, handle as well as the cars most Americans have become accustomed to driving."

THE AVERAGE AGE of the U. S. farmer is trending up.

Automobile Assembly Line Lingo

blacksmith — Metal finisher.
body in white — Raw metal finished body without paint.
boomerang — Any molding having a wide-open *U* shape.
boot — A cover for convertible top when in folded position.
buck — Any build-up which supports parts while work is being performed.
bull ring — Area of the assembly line where body shell is welded together.

EMPLOYMENT IN THE AVIATION INDUSTRY has dropped by 69,000 workers or 20% since the end of 1958.

ENGINE FAILURE in VTOL aircraft can cause a disastrous lift unbalance unless proper precautionary design steps are taken. The aerodynamic forces used to control lift unbalance in conventional aircraft cannot be relied upon at very low flying speeds. Ways to improve safety include: cross-coupling between the thrust producers so that they act as one; using a single lifting device which acts through the center of gravity and thus cannot unbalance the aircraft.

FIFTEEN YEARS AGO, many plastics materials now beginning to penetrate the automotive market in volume were just coming on stream. Other old timers — such as vinyl, phenolic, polystyrene, cellulose acetate, and butyrate — were already commercial. . . . Developments during World War II accelerated commer-

chips

from SAE meetings, members, and committees

cialization of some types of plastics . . . notably the ABS polymer blends, which were a natural outgrowth of early efforts to reinforce styrene-butadiene rubber.

THERE IS A STORY GOING AROUND about the teacher who was explaining the wondrous things which science has discovered about the universe. "Just think," she exclaimed, "the light we need comes all the way from the sun at a speed of 186,000 miles per second. Isn't that almost unbelievable?"

"Aw, I dunno," retorted one unimpressed youngster, "after all, it's downhill all the way."

THE PLASTICS INDUSTRY, since 1950, has reinvested 4% of each sales dollar in research and development, the Society of the Plastics Industry estimates.

TOTAL DRAG of a supersonic airplane is nearly three times that of its subsonic counterpart. Friction and lift drags are each greater than the entire drag of the subsonic airplanes; in addition, wave drag appears.

CONTINUED GAIN of diesel use in small European trucks is pointed up by the following percentages of 12,000–18,000 gvw trucks using diesels in . . . France, 50%; Sweden, 81%; England, 95%; Germany, almost 100%.

"BULL O' THE WOODS" type of communicating decisions to employees can leave a supervisor unpopular, even though he always makes the right decisions, a recent SAE panel on "Personnel Development" brought out. . . . A supervisor's decision often is unpopular, too, because the facts on which it was based are not known to his group. And, too often, the trouble comes from lack of communication of the facts from middle management to the supervisor (or from top to middle management). The supervisor ought always to be equipped to translate as well as transmit management decisions in terms of his own group. . . . If management doesn't so equip him, he would be wise to do his best to equip himself, the panel suggested.

RAM JET PRESSURE RECOVERY at Mach 4 can produce a potential static pressure rise of 157:1 if the airstream is completely decelerated isentropically.

THE 14-YEAR-OLD C124 GLOBEMASTER — a plane whose engine and most of its parts are no longer made — is the backbone of our American airlift, according to Senator A. S. Mike Monroney, chairman of the Aviation Subcommittee of the Senate Appropriations Committee. Speaking at a recent SAE Met Section Meeting, he said that 250 of the total MATS fleet of 425 planes are this obsolete craft. Service parts usually have to be hand-tooled and hand-tailored to fit the inspect and repair as necessary (IRAN) and modification requirements that come about every so often. It cannot fly with any reasonable payload over either ocean without using two or three island stops for refueling and servicing. It will still have some small value for short hauls and for emergency lift in the heat of battle on a short-range basis, according to Senator Monroney, but its service and repair cost, plus its obsolescence, make it a poor excuse as the mainstay of a modern American airlift.

A SUBSONIC JET does the work of about three typical propeller transports in seat miles per day. It is expected that a supersonic transport, in turn, will do the work of three to four subsonic jets.

ONE TIRE REMOVAL for every 12 landings with jets in 1960 — that's the reported experience of one airline operator.

GLASS FIBER or plastic components look promising for application in lightweight jet engines to be used for lifting VTOL aircraft.

QUALITY CONTROL organization is to the manufacturing process what feedback apparatus is to automated equipment, says Chrysler's C. G. Bauer. Just as the feedback keeps a piece of equipment operating properly within set limits, he points out, the quality control organization keeps the entire manufacturing process functioning properly within set limits. The feedback of the quality control group is the inspector. Without inspection, there is no quality control. By the same token, the accuracy of the inspection has a lot to do with the quality of the finished product.

20–25 POUNDS of adhesives are forecast for the 1970 car.

recent developments in

HEAVY-DUTY VEHICLES

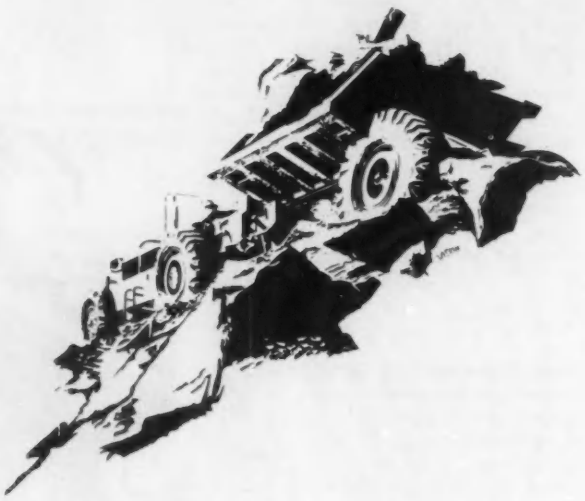
John Deere turns to sleeve and deck construction . . . 32

New power steering features increased flexibility . . . 41

Versatile suspension devised for military crawler tractor . . . 48

Tractor transmission with on-the-go shifts . . . 55

Oliver's n ew "1800" tractor engine . . . 62



John Deere turns to sleeve and deck

. . . for its new line of small engines for tractors and implements.

Principle allows for larger engine in given dimensional envelope and has production advantages.

Based on paper by

Willard H. Nordenson
John Deere Tractor Research & Engineering Center

and Russell Candee
John Deere Dubuque Tractor Works

THE sleeve and deck construction has been used on John Deere's line of small tractor and implement engines because it requires a minimum variety of pattern equipment and tooling. It also offers distinct advantages in foundry and machining procedures, and provides maximum engine displacement in a given dimensional envelope.

The design is based on a former production 145 cu in. integral-bore engine and its companion 217 cu in. 6-cyl engine. These engines had a 4½-in. cylinder spacing and a maximum bore size of 3¾ in. There were certain foundry difficulties with this engine. With the same cylinder spacing, a 3⅞-in. bore can be obtained with sleeve and deck construction, as well as providing replaceable cylinder elements. If individual wet sleeves had been used, only 3⅝-in. bore could be realized on this same cylinder spacing. There is a high degree of interchangeability between the new engines and the previous production engines. It was possible with the 115 cu in. size in the new line to replace an older 92 cu in. engine, which had no interchangeability of components with the other integral-bore engines.

Fig. 1 shows a sleeve and deck assembly being inserted into a 4-cyl block. The gasket on top of the block plays a very important part in the success of the arrangement, due to its great structural strength, combined with sufficient durability. The two hollow dowels, which are located coaxially with their respective holddown screws, locate the top end of the sleeve and deck assembly. Since the bottom end is located by the pilot bores in the block, the relationship of these dowels to the pilots is of great importance. There is an integral water manifold on the side of the block. The heavy flange structure at each end of the block and the ribbing along the bottom are provided for structural strength, since in tractor applications this block is part of the

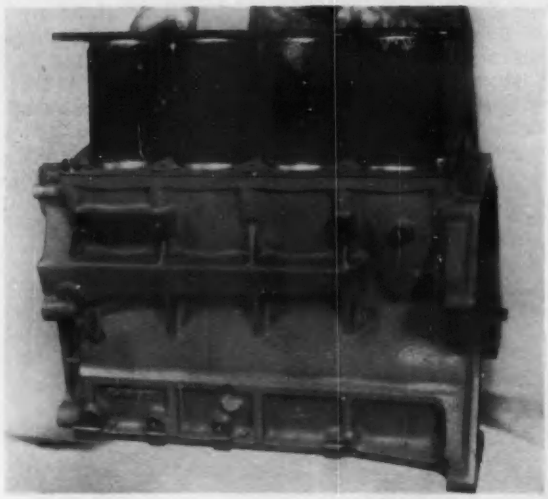


Fig. 1 — Sleeve and deck assembly being inserted into 4-cyl block.

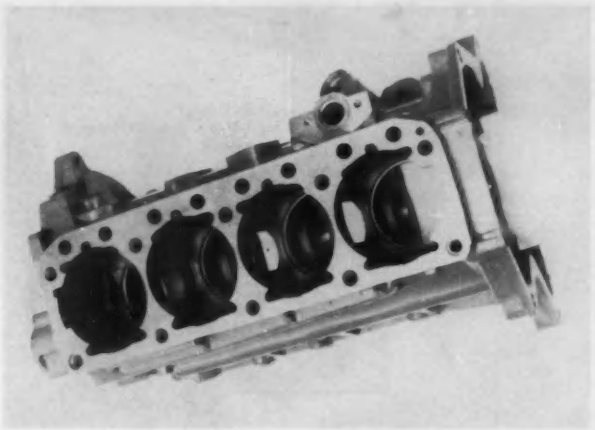


Fig. 2 — Top view of block, showing cylinder head holddown pattern and push-rod holes.

construction

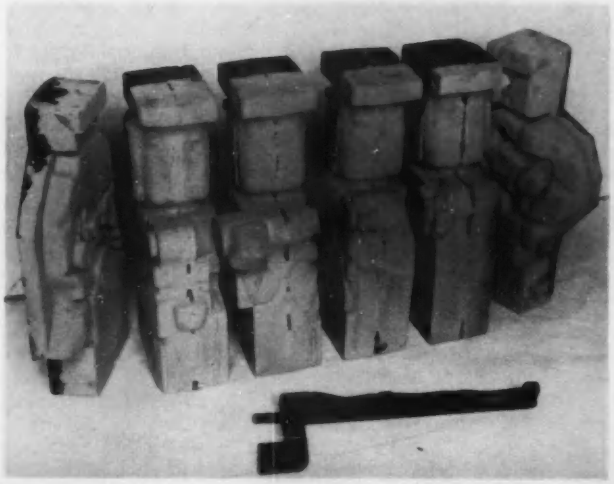


Fig. 3 — Cores for sleeve and deck block.

frame. The block extends 3½ in. below the crankshaft centerline to provide engine rigidity and a good structural connection at both ends of the block. Since the cylinder bores are not part of the block casting, alloying the block casting is not required, reducing cost and improving machinability. The only difference between gasoline and LP and diesel cylinder blocks is that diesel blocks have five and seven main bearings for four and six cylinders, respectively, rather than the three and four main bearings used on gasoline and LP. The close similarity is made possible by the use of a distributor drive injection pump on the diesel engines.

Fig. 2 shows the cylinder head holddown pattern and push-rod holes. The odd shaped notches are water passages that register with holes in the deck plate. They ensure circulation and elimination of steam traps at the top end of the sleeve. The holddown holes are substantially in line with the main bearing screws, which, in conjunction with the internal boss and web, practically eliminate eccentric loading, thus minimizing distortion. The sleeve pilot bores and seal counterbores show partially in the lower deck. The boss askew behind the distributor or injection pump bore is for a tachometer or hour meter drive by means of a single spiral gear

Fig. 4 — Cores for integral bore block.

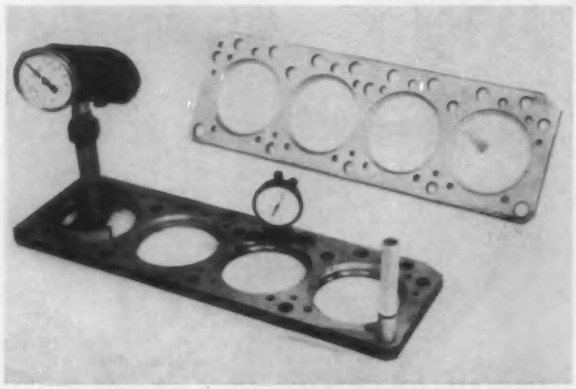


Fig. 5 — Deck plate.

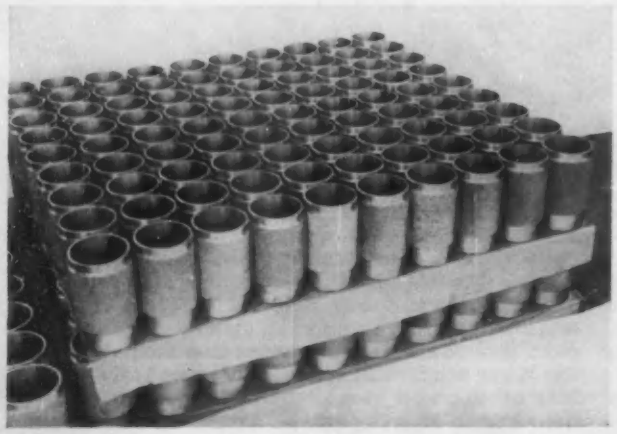


Fig. 6 — Machined sleeves.

meshing with the oil pump drive gear. The open internal construction of the block allows complete visual inspection of the block casting. Fig. 3 shows an exploded arrangement of the cores for making a sleeve and deck 4-cyl block. The club-shaped core at the bottom is the lower water manifold core, which can be integral with the block, due to elimination of the water jacket core. Fig. 4 shows the cores for a comparable integral bore block; note the sizeable jacket core. In addition, a separate water manifold had to be used, requiring a core, six fastening screws, and three gaskets. In the sleeve and deck block castings, all are identical except for the number of main bearings. Bore size is provided for by machining sleeve pilot holes to proper diameter. One pattern provides all the castings for a given number of cylinders. Coring is changed to provide main bearing variation.

Sleeve and deck assemblies used in the first experimental engines had ¼-in. deck plates and were used in unbridged blocks. They performed creditably on dynamometer testing and in field test tractors on gasoline engines. Later, however, when these assemblies were built into diesel engines, it was immediately evident that they lacked sufficient stiffness in the deck plate to handle the much higher peak pressures and more rapid pressure rise. At this point, the deck plate thickness was increased to 5/16 in., which doubled its stiffness. There was a significant improvement, but subsequent improvement in support in both block and cylinder head was required in the larger bore diesel.

The sleeve and deck assembly is made up of a machined deck plate (Fig. 5) and a set of cylinder sleeves (Fig. 6) brazed into the assembly (Fig. 7). This brazing is done in a furnace at 1200 °F. The sleeves are centrifugally cast and are purchased rough bored and cropped to length. They provide an excellent metal structure for cylinder bore use. However, the sleeve and deck assembly may not necessarily depend upon a centrifugally cast sleeve. All sleeve and deck assemblies of a given bore size and number of cylinders are interchangeable, whether for gasoline or diesel. Considerable development was required to refine the original brazed joint design to provide the desired uniformity. Fig. 8 shows the original joint design. While many successful development engines were built with this design, there were some engines that showed cracks in the region of the sharp corner, and there was difficulty in securing good filleting of the brazed joint, due to variation in clearance at the shoulder. The design shown in Fig. 9 not only eliminated the stress raising corner but provided a very dependable brazing condition.

A most amazing performance has been turned in by the little rectangular sealing ring at the lower end of the sleeve (Fig. 10). This seal is stretched over the pilot diameter and is a clearance fit with the counterbore OD until compressed axially when the cylinder head is tightened. Provision is made for "squirt" relief so that, under maximum compression due to tolerance buildup, there is minimum distortion of the sleeve. The machined surface on the OD of the sleeve just above the seal was added to ensure clearance and to provide "squirt" area under all conditions. Other than this refinement, the seal is almost unchanged from the original design.

The crankshafts for all engines in the line have

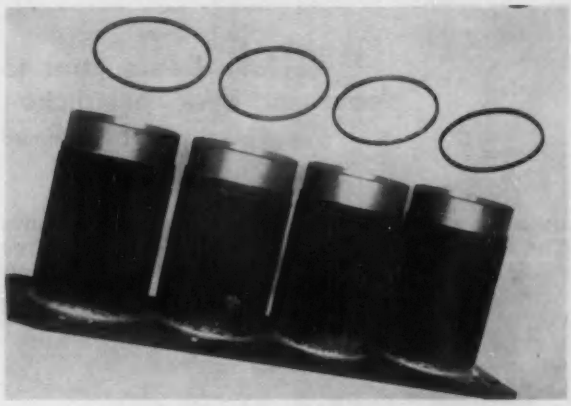


Fig. 7 — Sleeve and deck assembly.

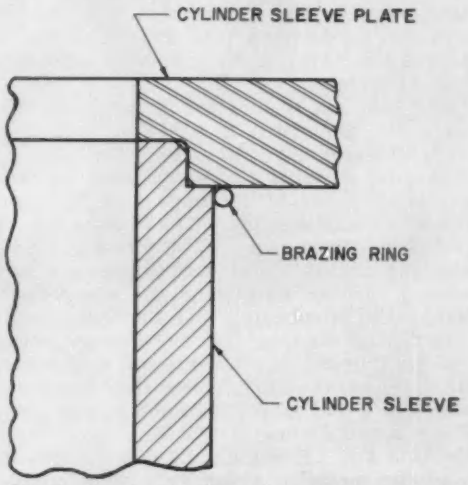


Fig. 8 — Experimental design for cylinder sleeve plate assembly.

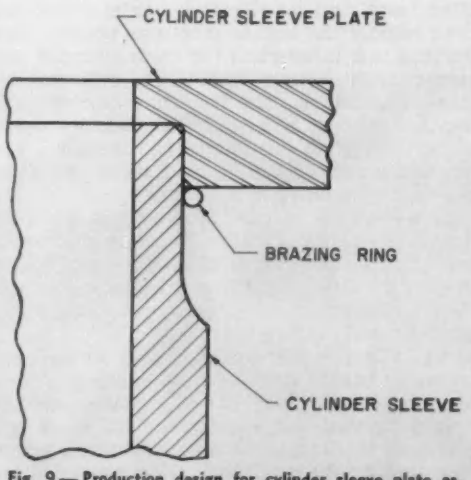


Fig. 9 — Production design for cylinder sleeve plate assembly.

John Deere turns to sleeve and deck construction

. . . continued

the same size main bearing journals and crankpins. The main bearings are 3 in. in diameter and the crankpins 2 5/16 in. in diameter. All bearing inserts are dimensionally interchangeable. One 4-cyl counterweighted crankshaft forging is used for both gasoline and diesel crankshafts simply by machining it differently, the only exception is the crankshaft for the 115 cu in. engine, where, in deference to its weight, cost, and 3 in. stroke, a separate noncounterweighted forging is used. One 6-cyl counterweighted crankshaft forging is used for both gasoline and diesel cranks.

The 3½ in. stroke engines have 29/32-in. pin overlap, the 3-in. stroke engine, 1 5/32-in. pin overlap. The cranks are made from 1046 F steel hardened overall to 241–286 Brinell and induction hardened on all journal surfaces.

One connecting rod is used for all engines. The center-to-center dimension is 6¼ in. It is made from 1041 steel hardened to 241–286 Brinell.

The pistons for gasoline and LP engines are cam-ground aluminum alloy, of the trunk type, with four rings, all above the piston pin. The pistons may be flat topped, convex, or concave. This, with a corresponding machining difference on the common cylinder-head casting, maintains the compression ratio, which is approximately 8/1 for the gasoline and 9/1 for the LP engines. On the diesels, pistons are also of the trunk type (cam-ground aluminum), with four rings above the pin and they have part of the combustion chamber machined in the piston head. The compression ratio is 19/1.

The gasoline and LP engines have a combustion chamber of the modified wedge type with inclined valves of generous diameter for free breathing. The intake valves have 1 11/16 in. outside diameter of the valve head and exhaust valves, 1⅜ in. outside diameter. The spark plug is located as far into the chamber as possible to shorten the flame travel and the burning time, and its electrodes extend into the chamber to handle the leaner mixtures better. The intake porting is symmetrical for each cylinder and is arranged to induce some swirl in the cylinder.

The diesel engines use the Ricardo "Comet" type of combustion system and utilize outwardly opening nozzles. No leak-off lines are needed. The valves are arranged vertically and have the same head sizes as the gasoline and LP engines.

One cylinder-head casting is used for all 4-cyl gasoline and LP engines. There are some machining differences. All 4-cyl diesel engines use one common machined head. One cylinder-head casting is used for all 6-cyl gasoline and LP engines. One 6-cyl diesel head is used.

The manifolds for the gasoline and LP engines are a one-piece intake and exhaust casting. There is no heavy mounting flange at the gasket surface. A somewhat limited gasket surface at each port opening is held in contact by long attaching screws and bosses high on the manifold. This design allows for better fastening, allows for more movement, and

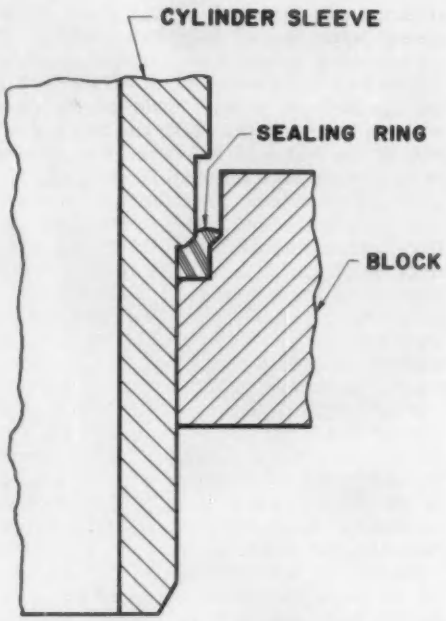


Fig. 10 — Sleeve to block seal.

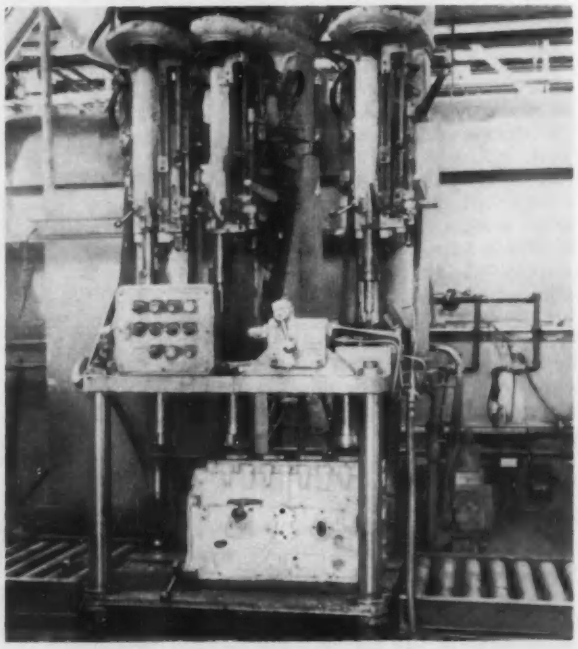


Fig. 13 — Block pilot bore dowel machining.

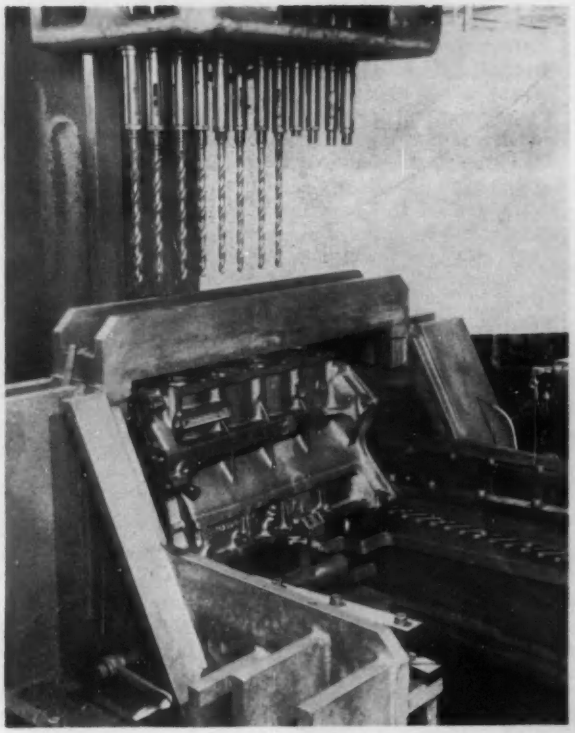


Fig. 11 — Top-side drilling on 4-cyl block.

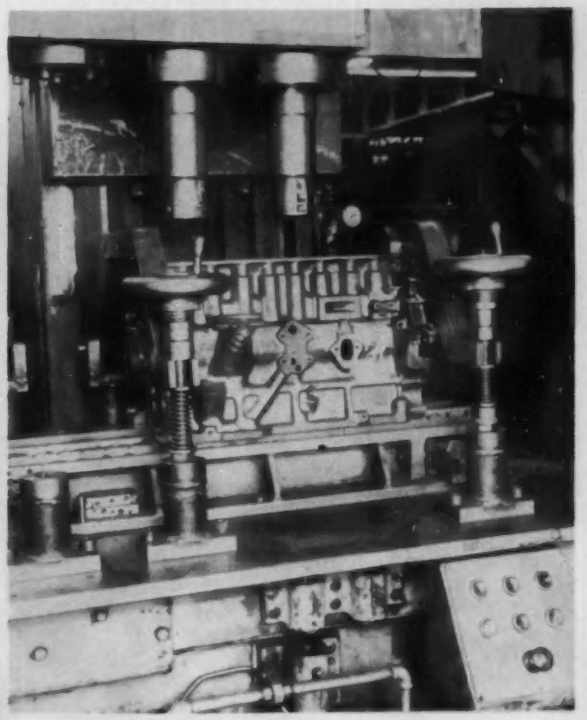


Fig. 12 — Block in place for pilot bore machining.

Fig. 14 — Sleeve as purchased.

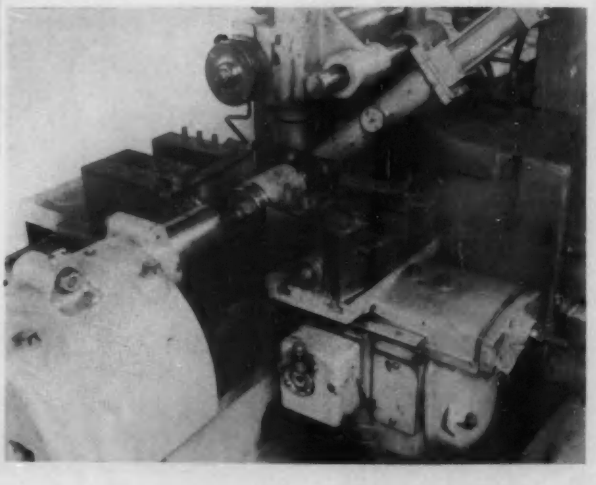


Fig. 15 — Sleeve being machined.

Fig. 16 — Punched deck plates.

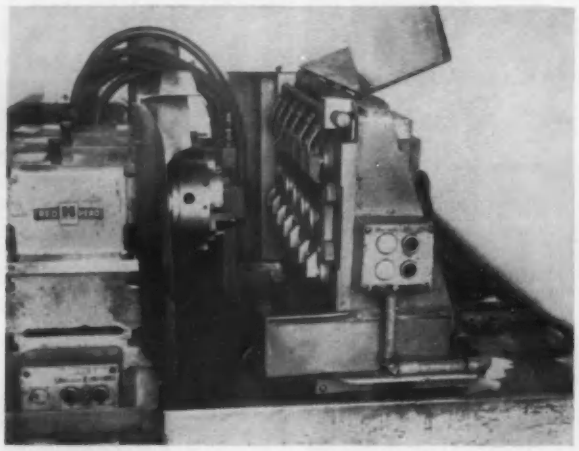


Fig. 17 — Deck plate being machined.

Fig. 18 — Deck plates being ground.

saves weight and cost. Heat is supplied on the under side and corners of the T rather than on the impinging side. Automatic mixture control is attained, providing moderate full-load mixture temperature and yet offering the higher temperatures necessary for part load and idle without the cost and the problems inherent in temperature control devices. This arrangement also puts the heat closer to the carburetor flange and minimizes icing. The same principle works well on either updraft or downdraft manifolds. The principle was first used 15 years ago on 2-cyl engines, and proved successful even with the heavier distillate fuels.

The diesel engines require separate intake and exhaust manifolds, since the intake and exhaust ports are on different head surfaces.

The fact that the complete line of 4- and 6-cyl engines requires only four block castings minimizes foundry and machine shop inventory problems. As previously stated, two of these castings differ from their mates only in the number of main bearings. Scrap due to casting defects with the sleeve and deck block is about one-third of that encountered with the integral-bore block.

All blocks, whether 4- or 6-cyl, gasoline or diesel, are machined over the same equipment. Fig. 11 shows some top-side drilling on a 4-cyl block. There is space in the fixture and in the drill head to accommodate the 6-cyl block. The block passes through numerous conventional machining operations. One of the operations significant to the sleeve, and deck construction is the machining of the sleeve pilot bores. A 2-spindle boring machine successively roughs and finish bores the cylinder sleeve pilots. This is a straight-through bore with step diameters to accommodate the rubber sealing rings on the liners. Fig. 12 shows the block in place for the pilot boring operations. For this operation and many others, the block is located in respect to reference holes in the pan rails. The sleeve pilots must be in very close alignment with respect to each other. The center-to-center dimensions must be controlled to gear center tolerances, rather than to the broader tolerances usually associated with cylinder spacing. A design feature of the engine is also illustrated. The block is so designed that a separate tappet side plate is not required, thus effecting a cost savings and eliminating a potential oil leak. In the final machining operation (Fig. 13) dowel holes are reamed on the top surface at opposite ends of the block in reference to the bottom pilot openings. These dowels engage the deck plate of the sleeve and deck assembly, assuring accurate positioning of the liners in the pilot bores of the block. The dowels also extend into the cylinder head to maintain alignment.

The manufacturing of the sleeve and deck plate assembly starts with the centrifugally cast sleeves received from the vendor rough bored and cut to length (Fig. 14). The sleeves are turned, chamfered, and faced at both ends (Fig. 15), and then cleaned in preparation for brazing to the deck or sleeve plate. Oil, surface graphite, and iron oxide are all removed. Processing of the deck plate starts with shearing the

Fig. 19 — Deck plate flux control.

Fig. 20 — Cylinder sleeve fluxing.

John Deere turns to sleeve and deck construction

. . . continued

3/8 in. thick stock to length and then punching all holes except the liner openings (Fig. 16). After a flattening operation, two locating dowel holes are drilled and reamed. The sleeve openings are then machined in respect to the dowels (Fig. 17). Following a furnance stress-relieving operation, the plates are ground on both sides, with the finish grind taking place to 5/16-in. thickness on a surface grinder utilizing a magnetic chuck (Fig. 18). Next, the dowel locator holes are finish-machined. This is followed by the finish size boring and counterboring of the sleeve openings. The plates are inspected for flatness, dowel hole location, and liner opening size.

Fig. 21 — Sleeve and deck prior to brazing.

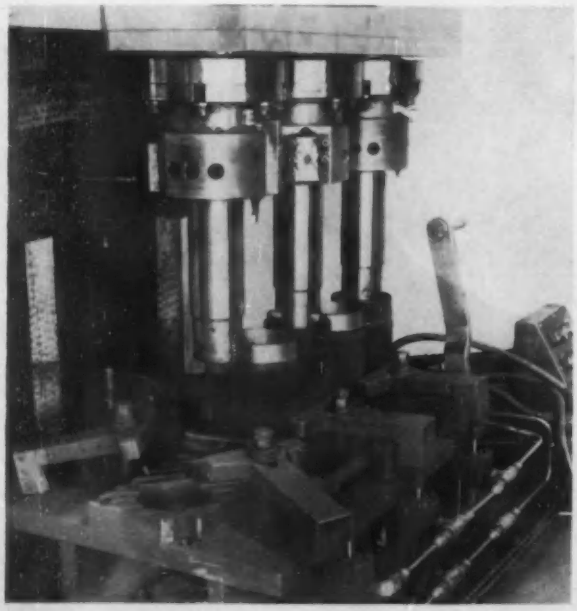


Fig. 22 —Sleeve and deck assembly — located in fixture where internal diameter is finish-bored at the same time that outside diameter open end of sleeve is flycut.

In preparation for assembly, the plates are individually sprayed to control the flow of brazing flux (Fig. 19). After the cleaning operation, each sleeve is, in turn, mounted on an expanding arbor (Fig. 20). The preformed brazing ring is slipped over the end of the sleeve. The sleeve is lowered and rotated in the flux. The sleeves are selectively fitted into the counterbore of the deck plate, assuring a snug fit. The assembly is placed on a tray where a 3-pronged, 5-lb weight is suspended on the open end of each sleeve (Fig. 21). The weight assures the sleeve staying square against the counterbore in the plate during brazing. During the early work, it was thought that the sleeves would need to be held rigidly with respect to each other and also with respect to the deck plate. Some massive fixturing was built to Siamese the assembly together for brazing. One of the problems with this arrangement was, that small dimensional changes during the brazing and cool-off cycles resulted in its being nearly impossible to remove the fixture without danger of breaking sleeves off the plate. A better and simpler solution proved to be the use of the free-state type of fixturing, with individual weights to assure the sleeve sitting squarely in the counterbore and free to move with temperature differential. Other than for the plates humping up a few thousandths of an inch during the cool-off portion of the cycle, there is little dimensional distortion attributable to the brazing operation. The humpup is largely offset by contouring the individual carbon trays on which each assembly rests while in the furnace. The furnace is maintained at 1200 F, with a total cycle time of 2 hr, only ½ hr being in the hot zone. The next operation is ultrasonic cleaning to remove any foreign material acquired in the furnace. The assembly is placed in a fixture to finish-bore the internal diameter and simultaneously to flycut the outside diameter open end of each sleeve (Fig. 22). The work is located from the dowel holes in the plate and rigidly clamped flat in the fixture. Accurate location of the flycuts in relation to the dowels in the sleeve plate is a key operation, as this is the portion of the liner that engages the block and is positioned by the block to deck plate dowels. Here again, alignment and center-to-center distances must be carefully controlled. Much of the early experimental work was done without the flycut on the sleeves; however, variations encountered in production dictated the addition of the operation. The boring setup consists of three spindles. Nnmbers one and three bores are machined simultaneously with one spindle idle. The work table is indexed. Numbers two and four bores are then machined. The 6-cyl assemblies are machined in the same setup with one index of the table utilizing the third spindle. The cylinder bores are individually honed, air gaged, and classified as to size.

To Order Paper No. 395A . . .
from which material for this article was drawn, see p. 6.

New power steering features increased flexibility

Based on paper by

E. H. Fletcher

John Deere Tractor Research & Engineering Center

THE full-power power steering system developed by John Deere for its 3000 and 4000 series tractors allows the steering wheel to be mounted in different positions, without change in the subassemblies, as in the row crop model shown in Fig. 1 and the utility model shown in Fig. 2. The fuel tank can be mounted directly over the spindle, as shown in Fig. 3. Where a spindle is not desired, cylinders can be used, as on the industrial model shown in Fig. 4.

Other advantages of this system include:

- Lower cost, through use of common pump.
- Full-speed turns can be made, even at low engine speeds.
- Full pump displacement is available for steering, although the operator cannot turn the steering wheel fast enough to use it all.
- Use of closed center valving has eliminated any tendency toward front wheel flutter.

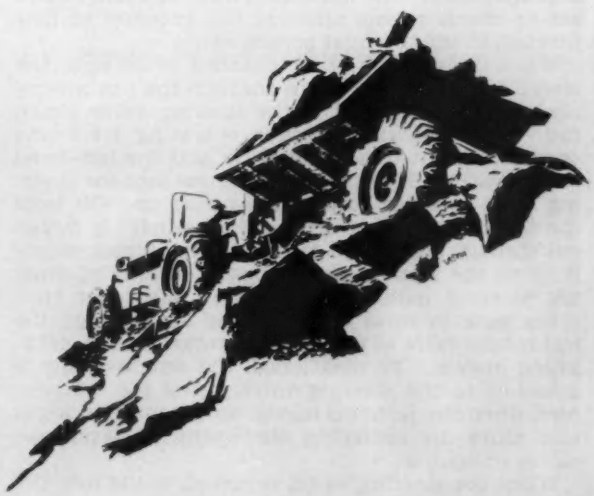
Description

All the hydraulic functions provided on the 3000 and 4000 series tractors, including power steering, are integrated into a central hydraulic system. This system is, in effect, made up of three parts:

- Oil supply.
- Hydraulic pump, control, and supply lines.
- Hydraulic function.

A diagram showing the oil supply for the central hydraulic system is given in Fig. 5. The transmission and differential case act as the oil reservoir. A gear pump driven from the transmission input shaft provides approximately 6 gpm at 100-psi maximum pressure. About 2 gpm of this oil goes directly to transmission lubrication. The rest is pumped through a 25-micron filter in the transmission case, then forward and through the hydraulic pump inlet manifold, the heat exchanger, and back to the transmission case. This circulation filters the oil, stabilizes transmission and hydraulic operating temperatures, and provides a slight supercharging pressure on the hydraulic pump. Two relief valves are used in the oil supply system: one to bypass the oil filter if the pressure drop exceeds 30 psi; the other to dump the circulating oil into the transmission case if total pressure exceeds 100 psi.

The circuit for the hydraulic pump, control, and supply lines is shown in Fig. 6. A variable displacement pump is connected directly to the front of the crankshaft. The displacement of this pump is



varied to meet the demands of each hydraulic function, while the pressure is held between 2000 and 2250 psi. All hydraulic functions are connected to a common pressure line and return through a common return line. This return flow is recirculated through the oil supply circuit by introducing it between the transmission lubricating pump and the oil filter. In this way, all oil is filtered before it enters the hydraulic pump.

Now, for the third part of the system; the hydraulic function: in this case, the power steering circuit shown in Fig. 7. This is a full-power steering system with provisions for manual steering in case hydraulic power is not available, as when towing the tractor.

Two subassemblies make up the complete power steering function. The steering valve shown in Fig. 8 is located at the steering wheel. The steering motor shown in Fig. 9 is located at the front wheel spindle. These two units are connected by high-pressure hydraulic tubing. A schematic drawing of these units is shown in Fig. 10. Four pilot-operated poppet valves are used to control oil flow to and from the steering motor, and adjusting screws are provided on each valve. The poppet valves keep leakage to a minimum without overlap. The pilot operation provides for low operating forces and the screw adjustments eliminate need for close manufacturing tolerances and allow compensation for wear.

Operation

Operation of the valves during a power turn to the right is shown in Fig. 11. High-pressure oil is taken from the common outlet of the pump. The pump, of course, increases its stroke as needed to provide the necessary flow. The unloading valve and relief valve act as check valves, allowing the pressure to flow through to the two inlet poppet valves.

When the steering wheel is turned to the right the steering worm moves down through the nut assembly, which is attached to the steering valve piston rod. This rotates the lower operating lever and opens the right-hand inlet valve and the left-hand return valve. High-pressure oil flows into the steering valve cylinder, forcing the piston up. Oil from the top side of the steering valve cylinder is forced out through steel tubes to the steering motor, where it turns the spindle to the right. Return oil from the steering motor flows through the other steel tubes back to valve assembly and out through the left return valve to the common return in the circulating system. As mentioned, the nut assembly is attached to the steering valve piston rod. Therefore, when the piston is moved up the nut and worm also move up, returning the operating lever and valves to neutral.

When the steering wheel is turned to the left, the

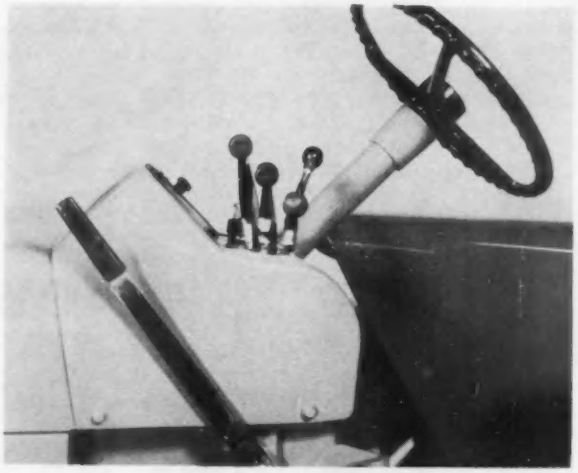


Fig. 1 — Row crop steering wheel location.

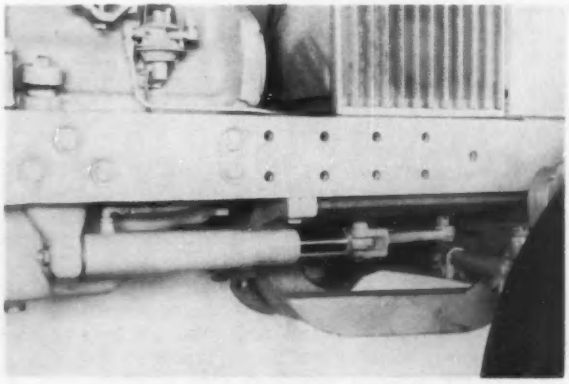


Fig. 4 — Industrial steering motor location.

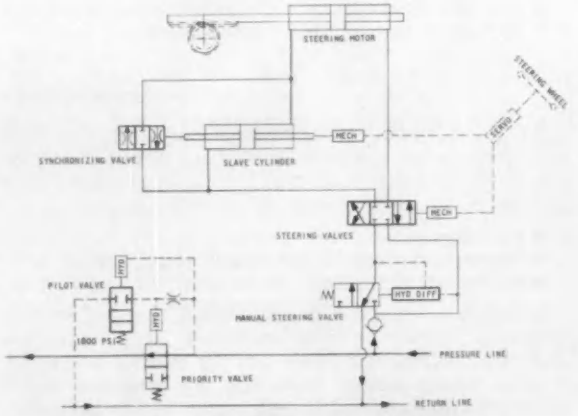


Fig. 7 — Power steering for central hydraulic system.

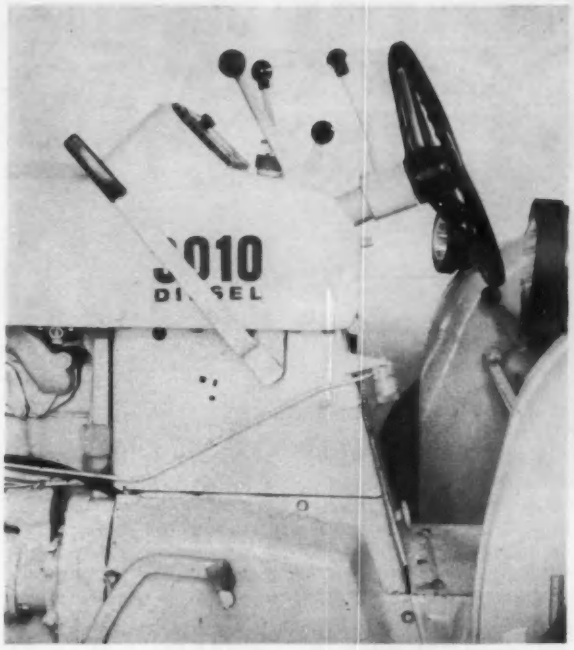


Fig. 2 — Utility steering wheel location.

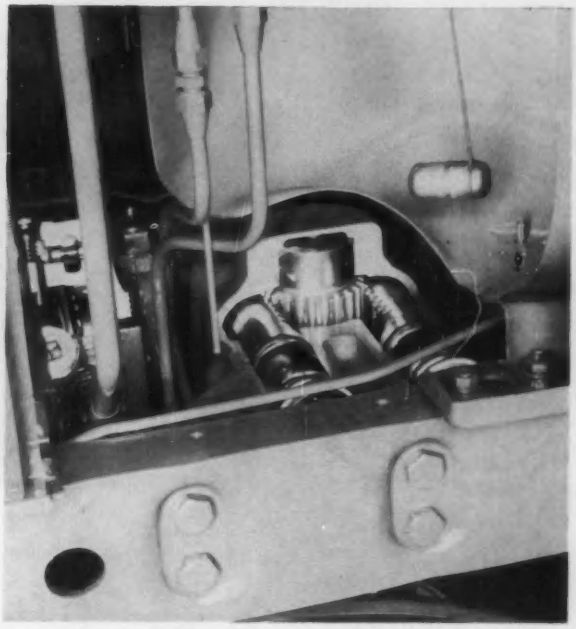


Fig. 3 — Steering motor location.

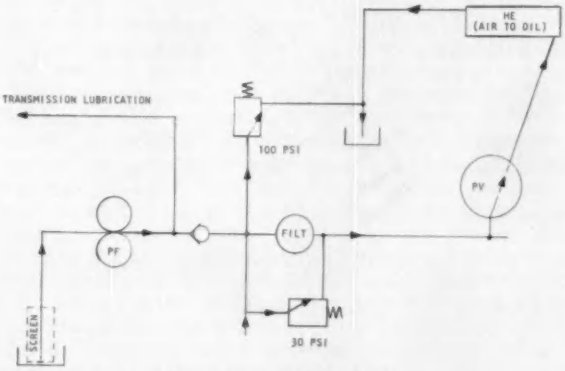


Fig. 5 — Oil supply for central hydraulic system.

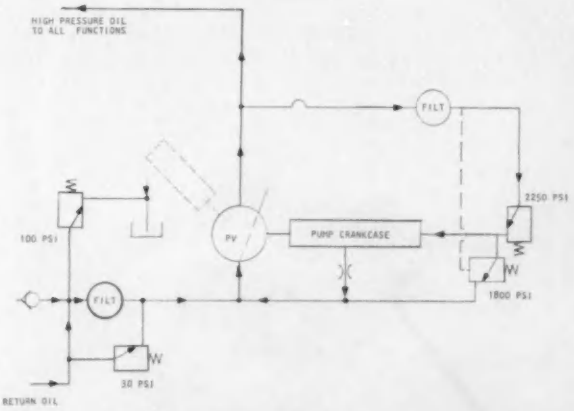


Fig. 6 — Hydraulic pump and stroke control for central hydraulic system.

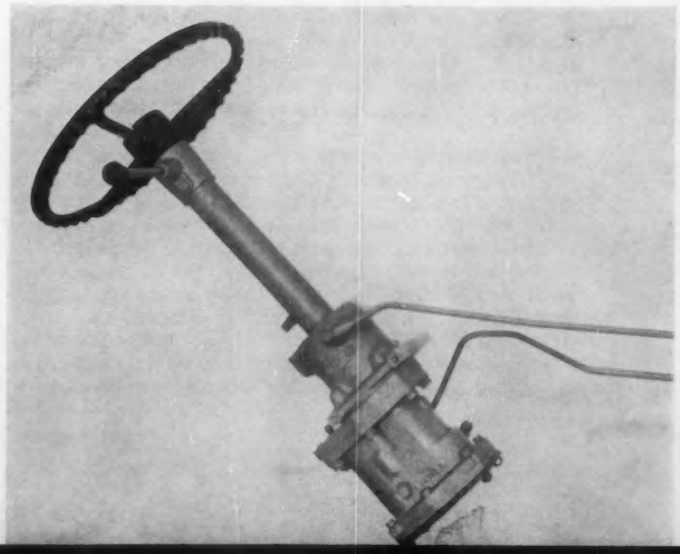


Fig. 8 — Power steering valve.

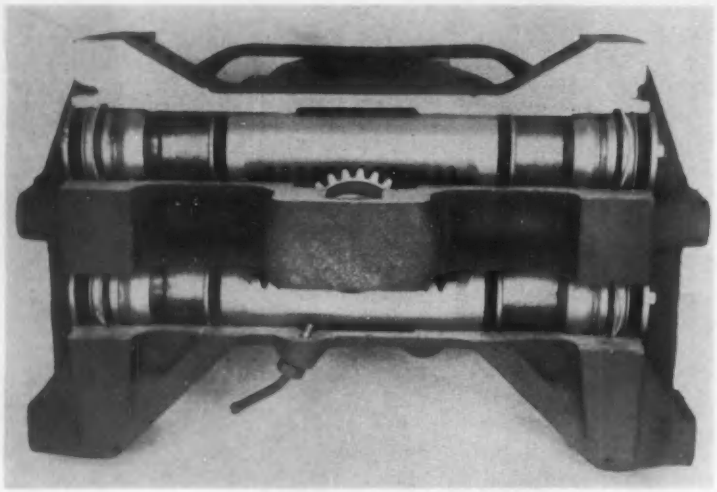


Fig. 9 — Power steering motor.

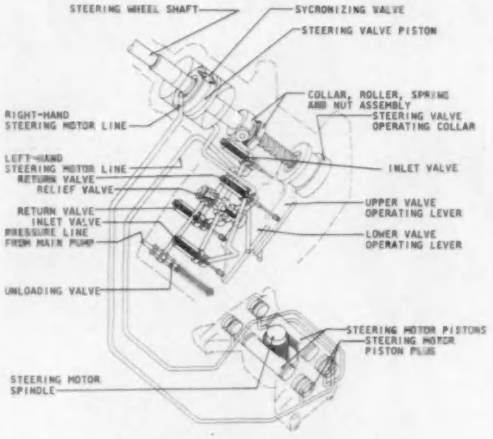


Fig. 10 — Schematic drawing of power steering mechanism.

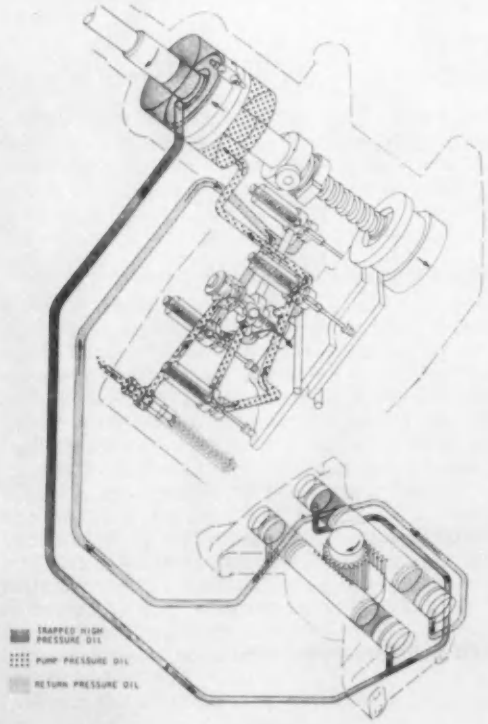


Fig. 11 — Power turn to right.

New power steering features increased flexibility

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worm and operating collar move up through the nut and cause oil to flow, as shown in Fig. 12. In this case, return oil from the steering motor enters at the top of the steering valve cylinder and forces the piston down before returning to the circulating system. This moves the nut, worm, and operating collar down again, returning the control valves to neutral.

So far we have turned to the right and to the left and only used half of the valves in the assembly. What are all the others for? As usual, the provisions for unusual conditions are more complicated than the basic function for which the unit is designed. The oil trapped between the steering valve cylinder and the motor must be relatively free from air. Therefore, two valves are provided in the steering valve piston and a bleed valve is provided in the top of the cylinder. These valves are used to bleed the motor, cylinder, and lines and to resynchronize the motor and steering wheel after bleeding. The valves in the piston also synchronize the steering wheel and spindle automatically in case of internal leakage.

The unloading valve and relief valve allows manual steering when hydraulic power is not available. The unloading valve is normally held open by operating pump pressure. When this pressure drops to the point where manual steering is required, the ball valve closes the inlet passage and opens the passage to the return line. This removes the pressure from the top of the relief valve and allows the passage from the return valves to the return line to close; making the steering cylinder, valves, and motor a closed circuit completely filled with trapped oil. Fig. 13 shows the system in this condition. The motion of the operating collar is limited by thrust surfaces in the valve housing. Therefore, if the steering wheel is turned when there is no hydraulic power, the operating collar will move endwise until it is stopped by the thrust surfaces, then the nut and piston will move, forcing oil from the steering valve cylinder to the motor to turn the spindle one way or the other, depending on which way the steering wheel was turned. Fig. 14 shows operation during a manual turn to the right and Fig. 15 shows operation during a manual turn to the left. Manual steering is intended for emergency use only, when power is not available.

The priority valve is another extra required for rather unusual conditions. The variable-speed engines used in the 3000 and 4000 series tractors allow operation at very low engine speeds. When using a number of hydraulic functions and operating at low engine speeds, it is possible to exceed the output of the hydraulic pump. If the load on the other hydraulic functions were less than that required on the steering, the steering could be affected. The priority valve is used to prevent this. Fig. 16 shows a cross-section of the valves, which are built into

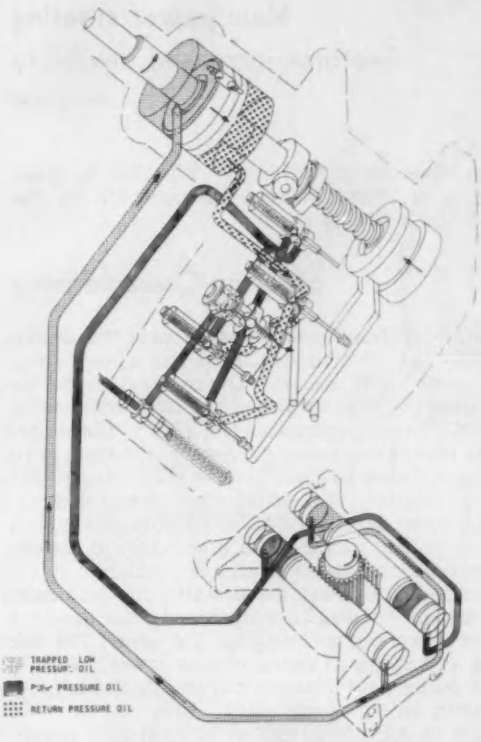

Fig. 12 — Power turn to left.

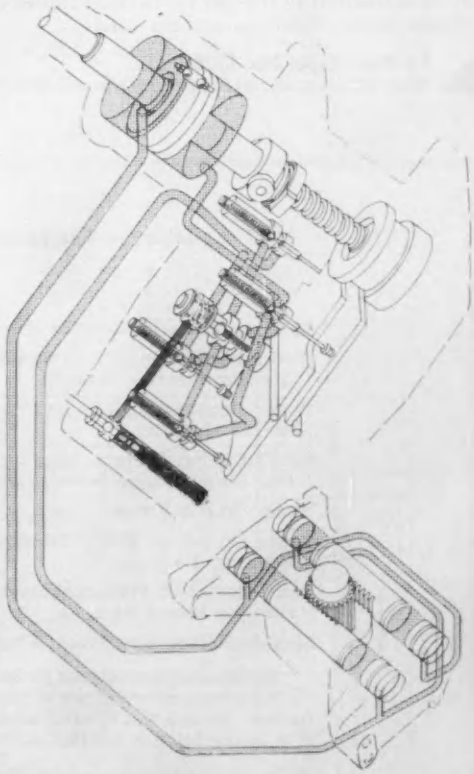

Fig. 13 — Power steering without hydraulic pressure.

New power steering features increased flexibility

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a junction block for the oil lines. The flow to other functions is restricted when the pressure in the steering drops below 1800 psi.

Steering Characteristics

How well does this steering system meet the design objectives? Let us compare it to the open center booster system used on John Deere tractors before and still used on most of the other tractors now on the market. Table 1 compares the 4010 to the model 730. This comparison can be seen more clearly in the bar chart shown in Fig. 17. The maximum steering rate is higher; the effort the operator must exert for a given rate is lower; the hydraulic output required from the pump for a given rate is lower; yet, the maximum torque available is higher.

How do the horsepower losses under no-load conditions compare? Input horsepower to the steering pump only when not steering on the model 730 was measured at 2.55 hp at rated engine speed. Fig. 18 shows the pump performance curves for the central system pump on the model 4010. Even though this pump has a maximum output of 25 hydraulic horsepower and serves steering, brakes, rockshaft, and remote functions, the losses at standby are less than those measured in the previous open center constant displacement steering system alone.

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from which material for this article was drawn, see p. 6.

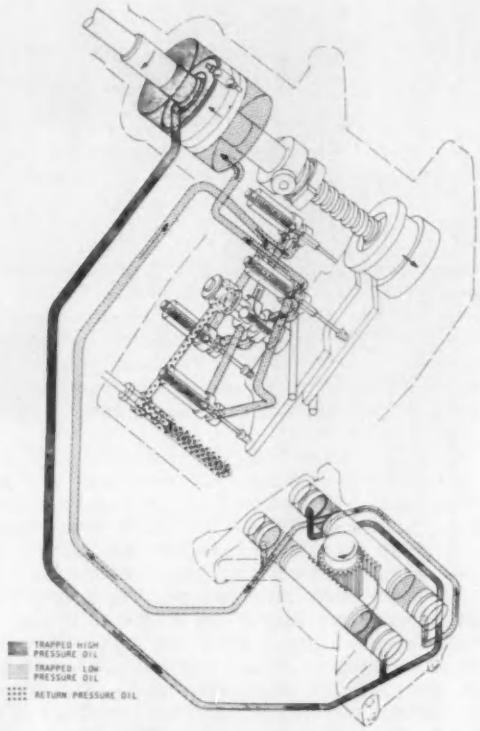


Fig. 14 — Manual turn to right.

Table 1 — Comparison of Old and New Power Steering Systems

	Old System JD Model 730	New System JD Model 4010
Maximum Steering Rate at Steering Wheel, rpm	75–129[a]	158–231[b]
Steering Effort on Rim of Steering Wheel at Maxium Steering Rate, lb	4.5–5.5	3.5
Power Required on Rim of Steering Wheel at 100 Rpm, hp	0.060–0.074	0.047
Oil Flow from Pump at Maximum Steering Rate and Rated Engine Speed, gpm	7.46	2.7–3.9
Pump Output Pressure, psi	950	2000
Power Output of Pump Required for Maximum Steering Rate, hp	4.14	3.15–4.55
Power output of Pump Required for 100 Rpm Steering Wheel Rate, hp	4.14	1.98
Maximum Torque at Front Wheel Spindle, in.-lb	12,300–14,900	17,300–17,900

[a] Maximum steering rate of the 730 was limited by a flow control valve.
[b] Maximum steering rate of the 4010 is limited only by the rated the steering wheel is turned. In this test it was limited by the 3.5-lb force applied at the steering wheel rim. If a larger force is applied, a faster rate will result.

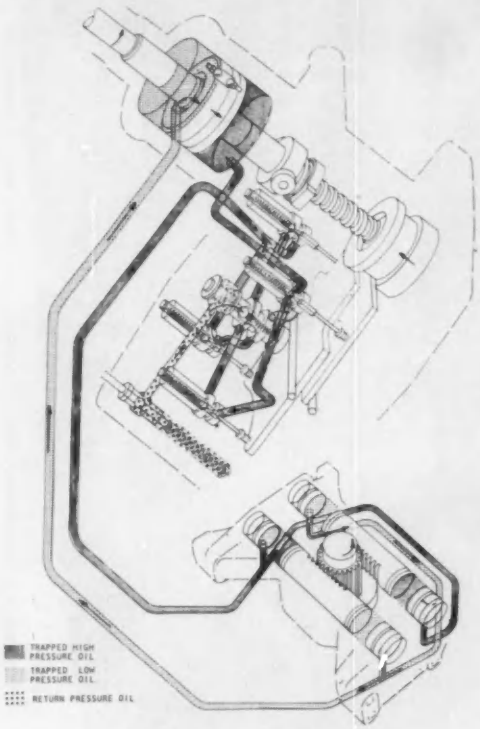


Fig. 15 — Manual turn to left.

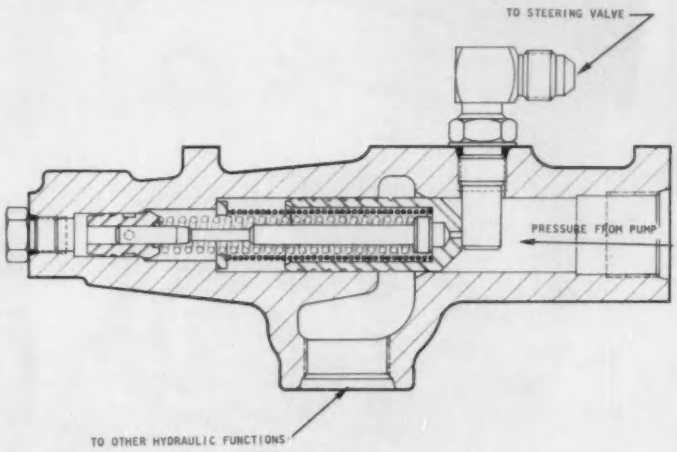


Fig. 16 — Steering priority valve.

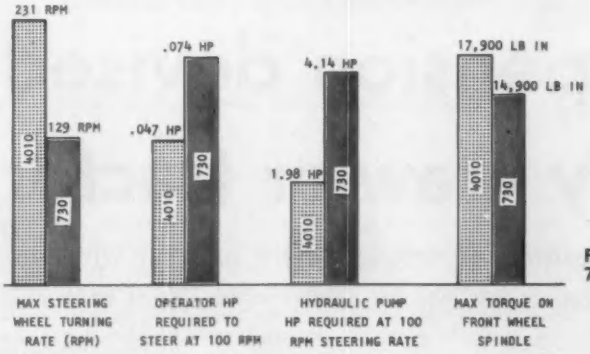


Fig. 17 — Steering characteristics — model 730 versus 4010.

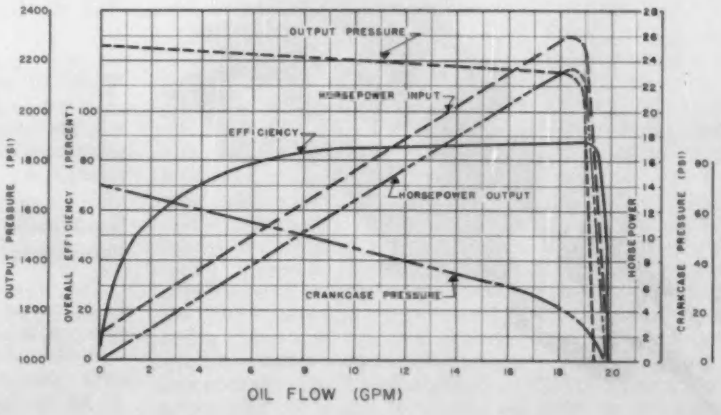
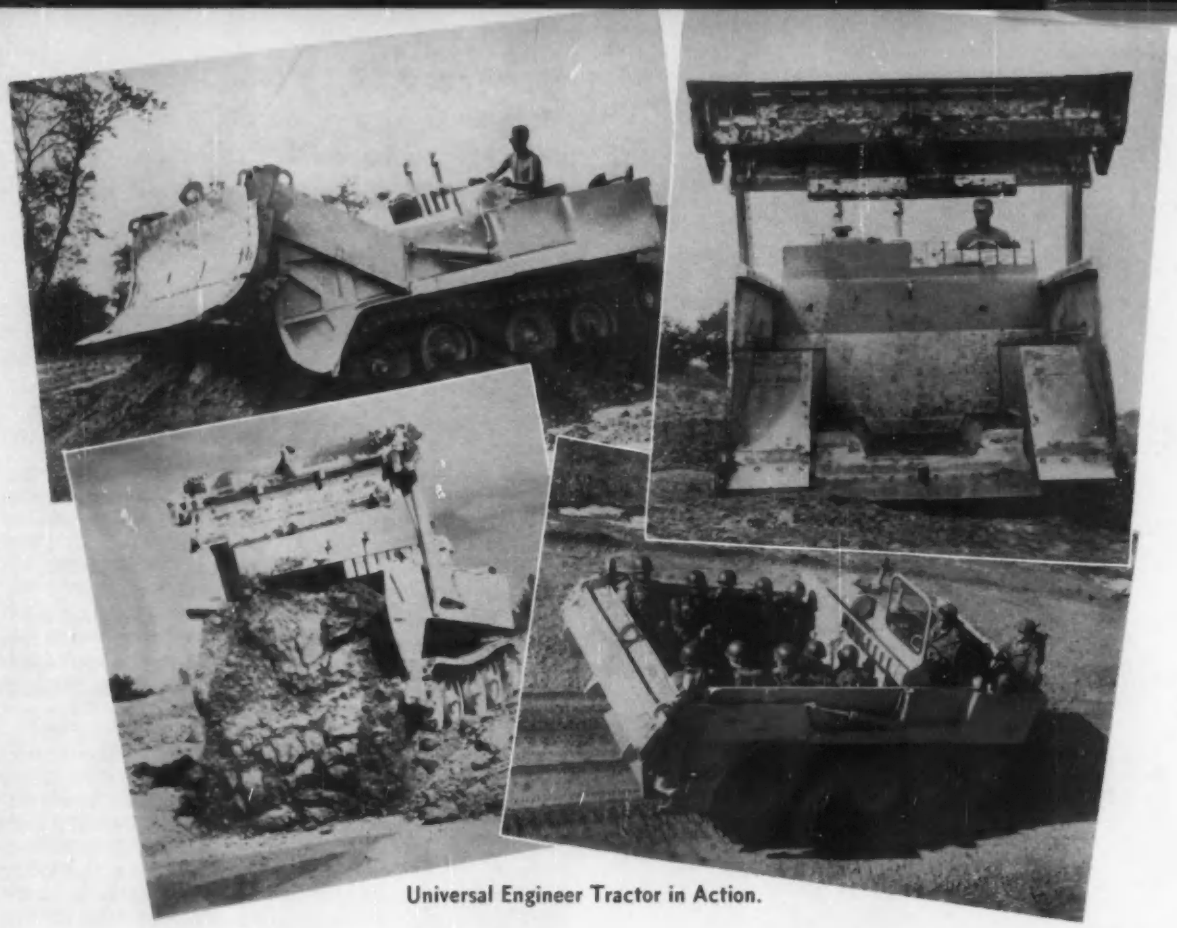


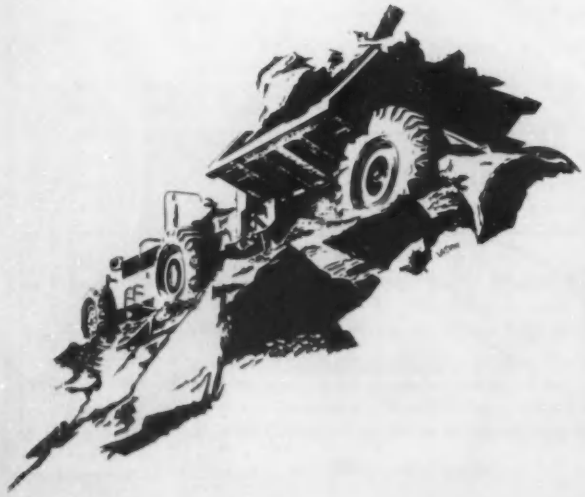
Fig. 18 — Pump performance.



Universal Engineer Tractor in Action.

Versatile suspension devised for military crawler tractor

System provides control of vehicle height and tilt with suspension in unsprung condition, in addition to usual features.



Based on paper by

R. K. Reynolds and E. Mayer

Construction Equipment Division,
International Harvester Co.

THE suspension system of the Universal Engineer Crawler Tractor allows the operator to control vehicle height and tilt with the suspension in the unsprung or rigid condition, as well as providing the usual springing, damping, and automatic leveling.

Suspension analysis; component design and testing

For sprung operation, it was planned to have all eight suspension units (each unit consists of wheels, arm, hydraulic actuator, valve, and accumulator) operate independently under dynamic loading. However, this suspension in the sprung condition had to be capable of automatic leveling under widely

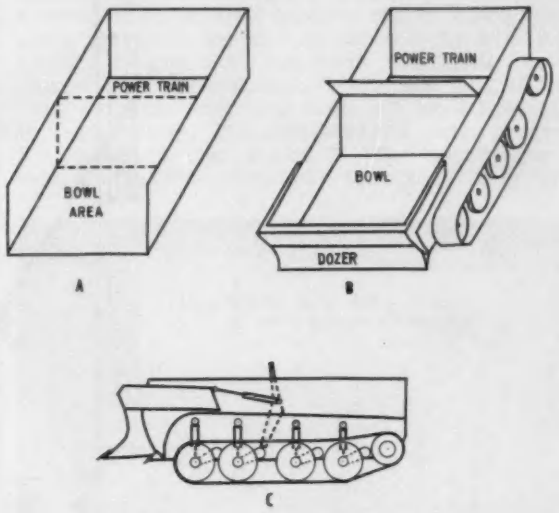
THE Universal Engineer Crawler Tractor is IHC's answer to the need of the U. S. Army for a lightweight, multipurpose earthmoving machine.

The inventors of the vehicle visualized a rectangular box minus the top and one end, as shown at A in the illustration. The bowl would be at the open end, the power train at the closed end. The next step (B) was to add a conventional ejector, which would separate the bowl area from the power train area, and an apron, which would close the open end of the box. Since the apron would be forward of suspension components, it was only logical to incorporate the dozer blade with it.

The lower half of the dozer was hinged for folding, so that the angle of approach could be increased, when desired, for cross-country traveling. Choosing track instead of wheels would not only simplify drive problems (two sprockets versus four wheels) but would also increase traction and mobility.

The key problem was how to raise and lower the cutting edges and how to design the suspension to provide springing during travel and rigidity during scraping and dozing. The design flexibility of hydraulics suggested the solution.

By attaching a hydraulic cylinder to each of the wheel arms (C), height and tilt could readily be controlled by the operator, and the hydraulic fluid would give the required rigidity. The same cylinders could transmit fluid to accumulators (gas springs) for sprung operation. The operator could choose either the sprung or the unsprung condition by remotely actuating valves that would connect or disconnect the accumulators from the hydraulic cylinders.



Basic design of Universal Engineer Tractor.

The prototype vehicle, which was completed in May 1960, has been tested extensively. Testing of a second-generation machine is expected to start in the near future.

Related here, in brief, is the design evolution of the suspension system for this tractor.

varying loads. Since only three sets of leveling valves could be used (to avoid conflict), the suspension units were connected to obtain a three-point suspension statically (Fig. 1). A three-point suspension was also desirable for unsprung operation. A crossover line between the actuators for the left and right rear suspension units located the effective support point midway between those units, and made feasible the vehicle feature of tilt operations.

A preliminary analysis of the vehicle's weight distribution revealed:

A. Maximum force on the cutting edge — which is desirable to start soil penetration — would result if the suspension's rear pivot line in unsprung was at the No. 4 wheels, as shown by Fig. 2.

B. The dozer blade would have maximum lifting force (desirable for moving stumps and boulders), and maximum stability if the front pivot line in unsprung would be at the No. 1 wheels (Fig. 3).

Suspension arrangements "A" and "B" are not ideal from the standpoint of vehicle flotation and suspension simplicity. As a result, it was desired to incorporate maximum flexibility in the prototype suspension, until actual testing could determine the best locations for these pivot lines.

C. The longitudinal center of gravity shifts substantially forward when the empty vehicle is loaded with dirt. The front wheel loadings thus varied widely, from less than 1000 lb per wheel arm empty to more than 6000 lb per arm when the bowl is loaded. This large ratio (over 6/1) required the use of two accumulators per front unit (Nos. 1 and 2), one precharged to a low pressure, the other precharged to a higher pressure. The resulting spring rate curves are shown by Fig. 4. This wide loading variation also required that the leveling valves be actuated in sprung operation when the arm moves above or below its normal position.

Large variation in front wheel loading created another problem. When the operator disconnects the accumulators from the hydraulic actuators at the start of a bowl loading cycle, the pressures in the actuators and accumulators are identical and low; when the bowl is loaded, pressure in the front actuators is high. Some means had to be devised to raise the accumulator pressure up to or above the actuator pressure. One way would be to add balancing valves, so that both pressures would always be equal. However, the simplest solution was to take advantage of the leveling valve circuitry. By having the "fill" leveling valve connected between the wheel valve and the accumulator, and the "drain" leveling valve connected between the hydraulic actuator and the wheel valve, the "fill" leveling valve would add oil to the accumulator until its pressure

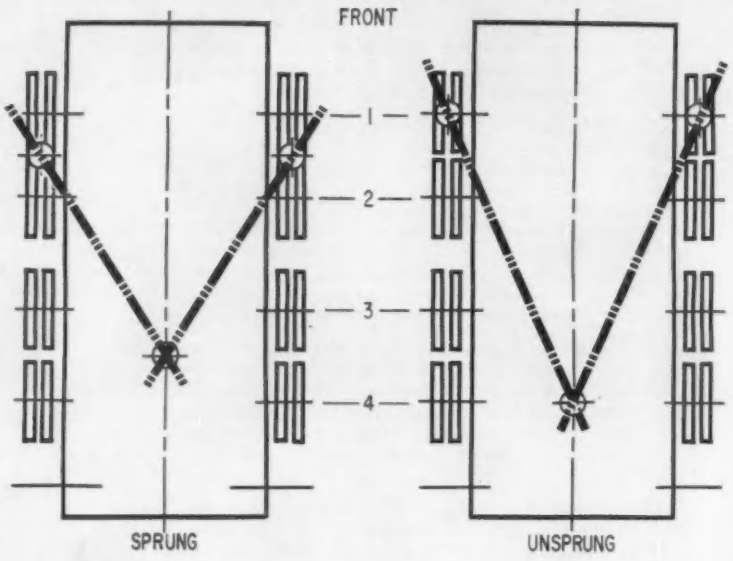


Fig. 1 — Plan view schematic of suspension reaction points.

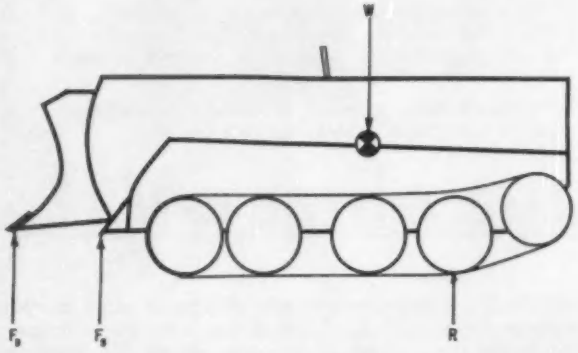


Fig. 2 — Vertical force analysis. W = weight, empty; F_D = force at dozer cutting edge; F_S = force at scraper cutting edge; R = reaction.

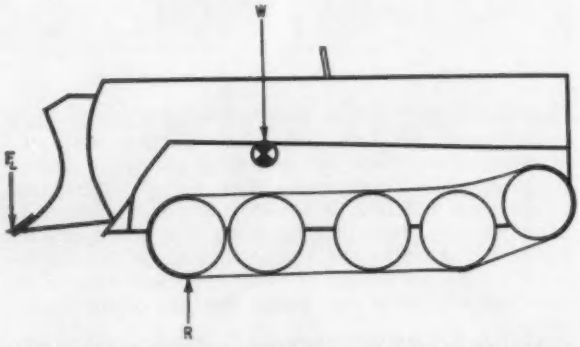


Fig. 3 — Vertical force analysis. W = weight, loaded; F_L = lifting force, dozer blade; R = reaction.

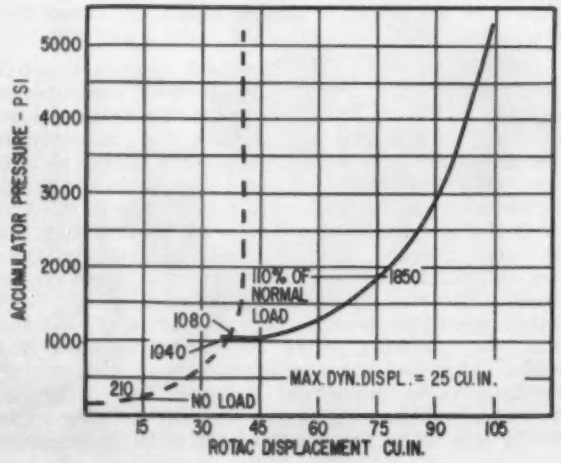


Fig. 4 — Spring rate curves for front wheels.

Versatile suspension devised for military crawler tractor

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equalled that in the centralized circuit. Minimum pressure in the centralized accumulator circuit is slightly higher than the maximum anticipated static pressure in the hydraulic actuators. Consequently, whenever the body is lowered to pick up a load, the accumulators are automatically pressurized to prevent any vehicle drop when the actuators and accumulators are once again connected for sprung operation.

The front wheels have sufficient travel to permit the scraper cutting edge to dig 6 in. below grade level. However, this capability in amount of wheel travel could prove disastrous during high-speed cross-country operation; that is, the scraper cutting edge could penetrate the ground if the vehicle pitched sufficiently. A means to avoid this possibility was to add retractable upstops at the front wheel positions (Fig. 5). During sprung operation, these upstops would limit wheel travel to 6 in. above the normal position. When the operator pushes the unsprung control lever, the upstops would be automatically retracted at the same time that the wheel valves were being actuated. Incidentally, sprung upstops for the Nos. 1 and 4 wheel arms have rubber pads attached to reduce impact forces.

The physical design aims for the suspension unit were to obtain a cartridge type of design, permitting ready installation and removal of the units from the vehicle; to incorporate leveling valves, which would sense arm position; and to combine the five functional components (actuator, manifold, valve, dampener, and accumulator) into one unit, so that high dynamic pressures need not be transmitted through fittings. The results of the design program are shown in Figs. 6 and 7. The advantages of rotary actuators (hereafter termed Rotacs) over

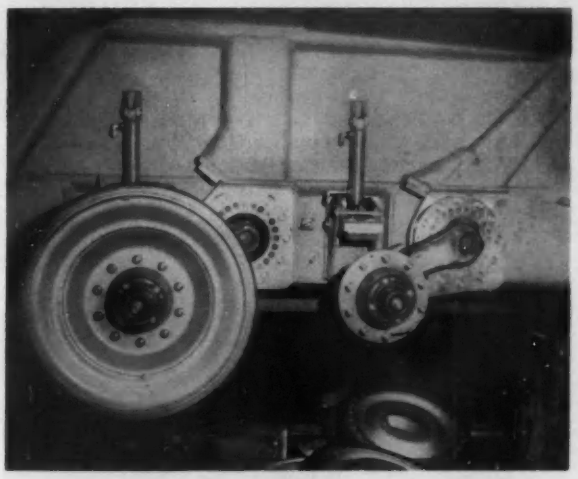

Fig. 5 — Front suspension units and retractable upstops.

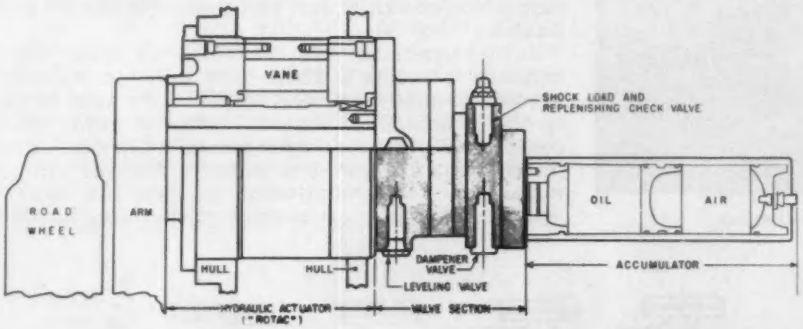

Fig. 6 — Cross-section of hydropneumatic suspension unit.

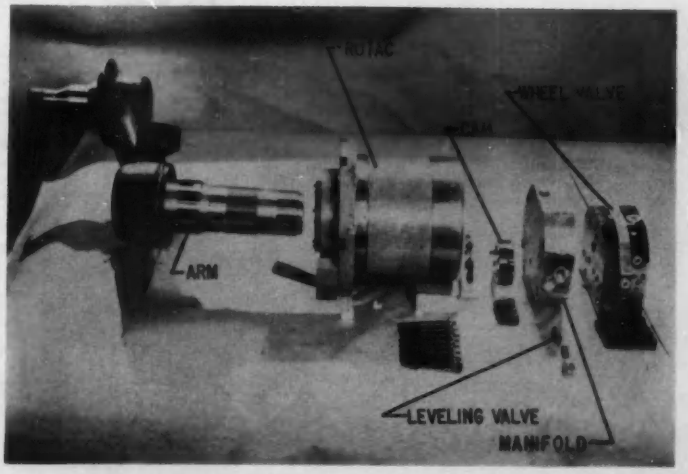

Fig. 7 — Exploded view of front suspension unit (without accumulator).

Versatile suspension devised for military crawler tractor

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hydraulic cylinders may be summarized as follows:

1. Less space is required (thus permitting greater bowl width and capactiy).
2. Body structure is simplified.
3. Plumbing is more accessible, installation and removal of suspension unit improved.
4. Hoses are not required.
5. The Rotac serves as a combination hydraulic actuator and wheel arm housing.
6. The normal internal leakage of a Rotac increases oil circulation to better dissipate the heat that is created by the dampener.

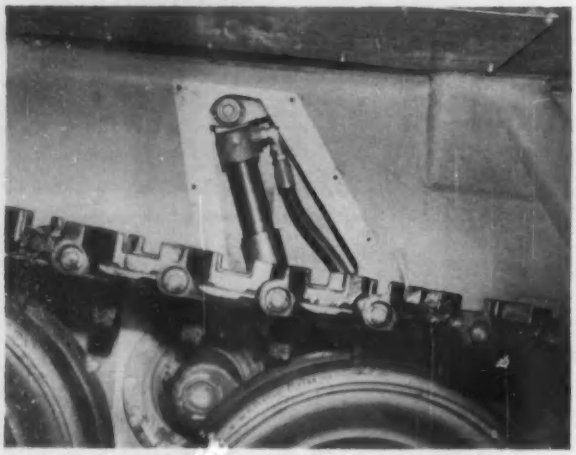


Fig. 8 — Cylinder for rear suspension unit.

The disadvantages of Rotacs are the lack of experience in this type of application, and the leakage characteristic. This internal leakage is an advantage to dissipate heat, but made it difficult to maintain a fixed pivot point in the rear end (at Nos. 3 and 4 wheels) during the work cycle. Were the actuators in the rear suspension units to leak, tilt operation would not be possible after a short period of time. Consequently, it was decided to use Rotacs in the front suspension units and hydraulic cylinders (Fig. 8) for the rear suspension actuators in the prototype vehicle.

An aluminum manifold is bolted directly to the Rotacs; its function is to consolidate the three outputs of the Rotac, and to house the two leveling valves. The cam which actuates the leveling valves is bolted onto the end of the arm shaft. The wheel valves are bolted directly to the manifold. They are a slide type of valve, and include the relief and dampener valves. Incidentally, the dampener functions only on rebound. The accumulators are similar to the commercial piston type, except for the high strength requirement (20,000 psi minimum burst strength) and a special end, which permits screwing the accumulator directly into the wheel valve. They are precharged with dry nitrogen gas.

Two suspension units were mounted on an experimental Ordnance high-speed tracked vehicle, which, in sprung operation, was driven over a 4-in. bump at speeds up to 22 mph. These tests showed that pressures in the accumulators do not exceed 5000 psi, even though simultaneous pressures in the Rotac and wheel valves were approaching 10,000 psi.

As a result of successful component testing, the suspension design of the first prototype (UET) was finalized (Fig. 9).

Each suspension unit contained all basic components, including a wheel valve and accumulator. Several manually operated needle valves were added to the plumbing so that the effective pivot lines could be shifted for experimental purposes. The piston pump had a 25-gpm capacity, 6000 psi normal rating, and was manifolded to split the output equally. This pump is capable of operating at 8000

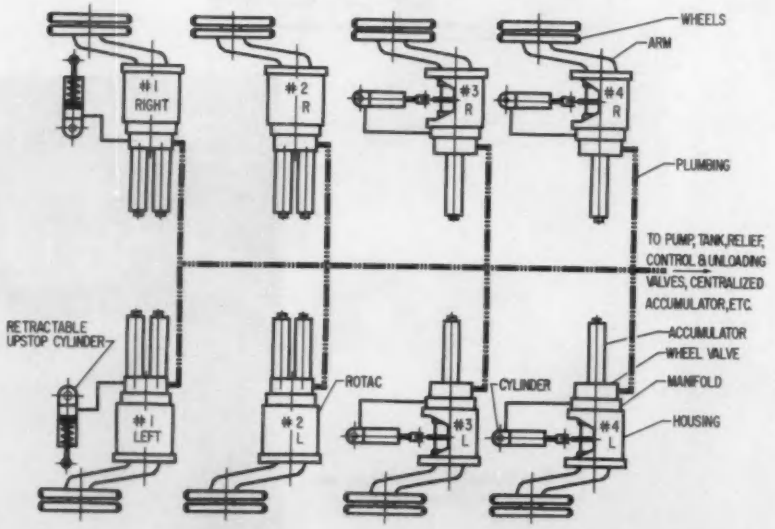


Fig. 9 — Schematic diagram of first hydropneumatic suspension.

psi for short periods of time. This pressure (8000 psi) is desirable if the front pivot line is located at the No. 1 wheel. The control valves were of the closed-center, slider type. A pressure regulator valve controls the 2300–2700-psi pressure in the centralized accumulator circuit; this circuit furnishes oil for the leveling circuits and the wheel valve actuation.

The mechanical components of the suspension are relatively conventional. The track is an Ordnance type with the following characteristics; 18-in. width; cast-steel shoe; rubber bushed, single-pin design; center guide; and removable rubber track pad. The 28-in. diameter wheels are stamped from aluminum plate and welded, and have a solid rubber tire and a riveted-on steel wear ring. The aluminum wheel hubs are a standard Ordnance part. The novel means to adjust track tension is shown in Figs. 10 and 11. The entire final drive is rotated about the input pinion centerline by means of an adjusting screw.

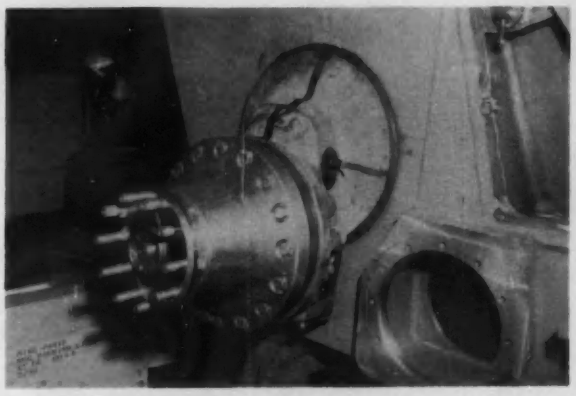


Fig. 10 — Final drive.

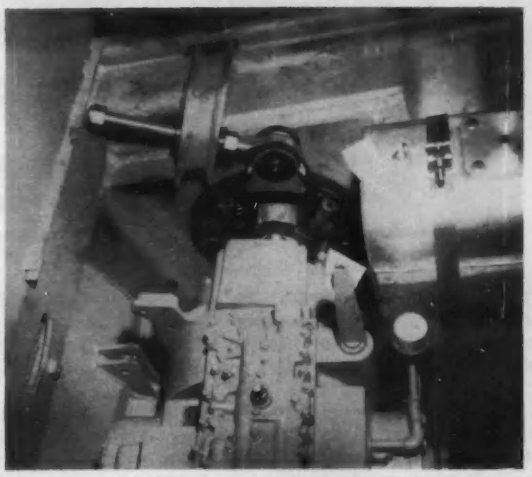


Fig. 11 — Track tension adjusting screw on final drive.

Test results of first prototype (UET)

The first UET prototype had a weight of 20,000 lb empty and 40,000 lb loaded, and a top speed of 30 mph. Testing to date indicates that the basic components of the suspension unit (Rotacs, leveling valves, manifold, wheel valves, and accumulators) are very reliable. The suspension fulfilled the design requirements both in sprung and unsprung operation. In addition, testing indicated that considerable suspension simplification was feasible:

1. Dozing capability with the front pivot line midway between the Nos. 1 and 2 wheel positions did not differ appreciably with that when the No. 1 position was the unsprung reaction line. As a result, Nos. 1 and 2 suspension units could be connected together (hydraulically bogeyed) at all times, both sprung and unsprung. This permits a reduction of components (valves and accumulators) and of the maximum pressure required for the suspension to 4000 psi.

2. Connecting No. 3 to No. 4 suspension unit moves

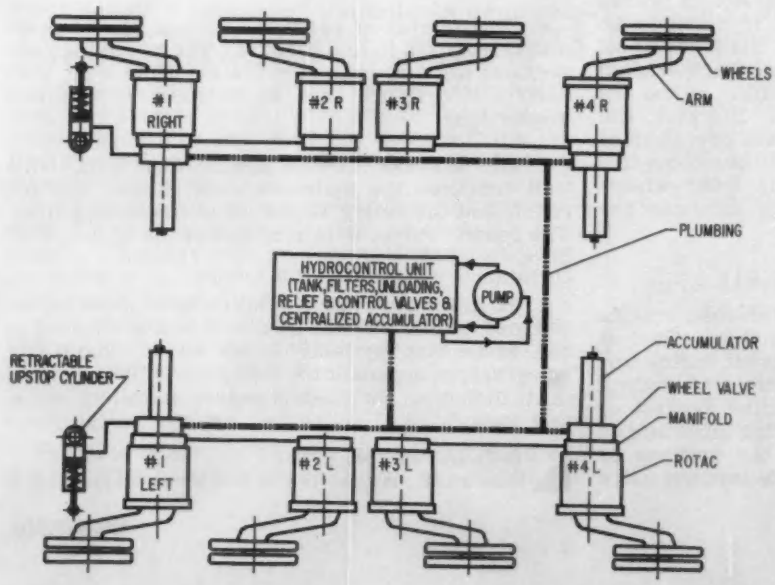
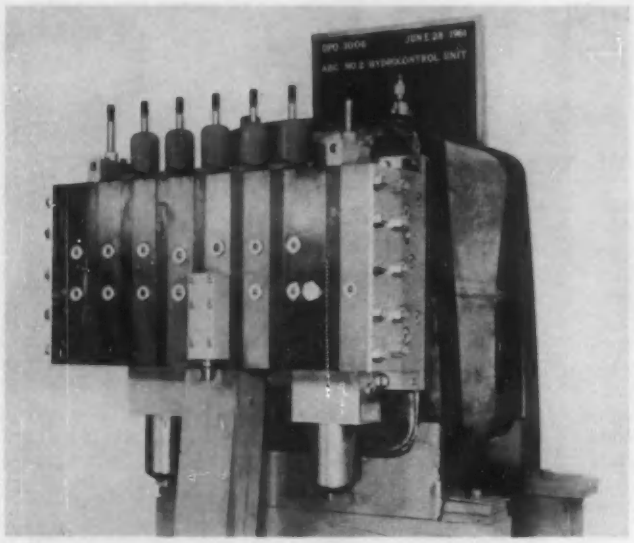


Fig. 12 — Schematic diagram of second hydropneumatic suspension.



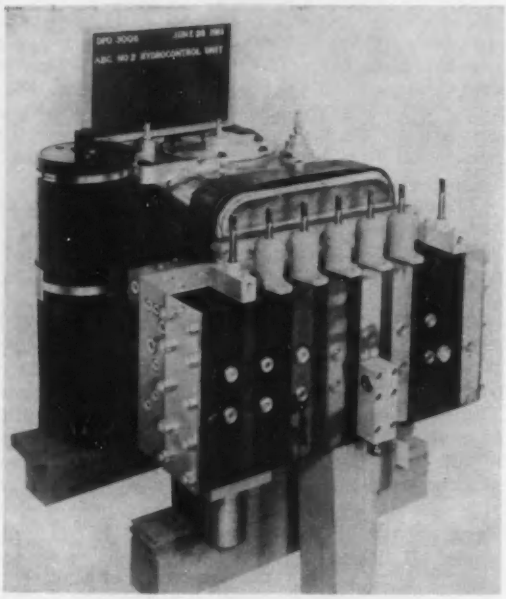


Fig. 13 — Views of Hydrocontrol unit.

Versatile suspension devised for military crawler tractor

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the rear pivot line forward and lowers the penetration force of the scraper cutting edge from 5000 lb to 3000 lb. The latter force was still sufficient, thus permitting us to bogey the rear suspension units.

3. When the tractor is empty or lightly loaded, track tension tends to snub movement of the front wheel. This result led us to question the value of the low-pressure accumulator for the front suspension units. Jury test rides on roads and cross-country, with and without the low-pressure accumulators operating, disclosed little appreciable difference in ride comfort in the bowl.

4. The double-acting feature of the Rotacs proved to be essential for this machine. In traveling in an arc from normal to full-up position, the front wheel stretches the track. This additional track tension hinders complete lowering of the vehicle unless the track is quite loose to begin with. However, the double-acting Rotacs, providing power operation of the wheels in either direction, readily overcome this difficulty. In addition, raising the front wheels during amphibious operation greatly increases the water propulsion efficiency.

Second-generation machine (UET-E1)

For the second generation of the Universal Tractor (Fig. 12), it was decided to change the method of height control for the rear support point during unsprung operation. A novel arrangement of leveling valves will be used to maintain close control of mean height at the vehicle rear during unsprung as well as sprung operation, despite the problem of tilt operation. Adoption of this new leveling valve arrangement permits use of Rotacs at all positions, greatly aiding standardization. This change, plus experience gained from the first prototype, led to the following improvements in the second-generation vehicle:

1. Lefts and rights are no longer required for the wheel arms, Rotacs, manifolds, and wheel valves.

2. Eight Rotacs will be used instead of four Rotacs and four cylinders.

3. The number of wheel valves has been reduced from eight to four.

4. The number of suspension unit accumulators has been reduced from twelve to four.

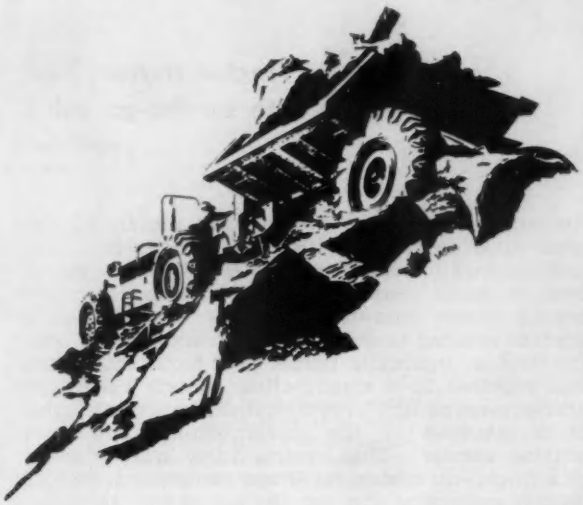
5. The retractable sprung upstops have been reduced from four to two.

6. The number of hydraulic fittings has been reduced from 220 to less than 80. The plumbing connections are now primarily the manifold type, with each unit designed in a single-plane to facilitate production.

7. Fig. 13 shows the new Hydrocontrol unit. This unit combines the hydraulic tank; filters; control, relief, and unloading valves; plus connecting lines. The control valves were changed to the open-center type.

8. To minimize vehicle weight and improve maintenance, aluminum was used as much as feasible in the suspension system: Rotac heads, manifolds, wheel valves, accumulator pistons, and Hydrocontrol unit, including the control valves, manifold block, and tank.

To Order Paper No. 399B . . .
from which material for this article was drawn, see p. 6.



A boon to farmers—

Tractor transmission with on-the-go shifts

Based on paper by

L. E. Elfes

Massey-Ferguson, Ltd.

THE MF-65 "Multipower" transmission developed by Massey-Ferguson for farm tractors was designed to meet the following basic requirements:

- **To have optimum balance between complexity, cost, and tractor flexibility in the field. This has been obtained by providing for powershifting between two speeds in each of six ranges in the forward direction. (See Fig. 1.)**
- **To have a continuous power flow through the drive train, plus a smooth shift at all loads and speeds. This has been met by the combination of an overunning clutch, with a single powershifted clutch unit. (See Fig. 2.)**
- **To fit the present transmission housing, with only minor machining changes — due to limitations of cost, plus present tooling.**

First design studied

The first design, based on these criteria, utilized a hydraulically actuated multiplate wet clutch, in

NEW transmissions are being developed for heavy-duty vehicles, such as farm tractors, off-high-way trucks, and earthmoving equipment. These units contain such features as finger-tip on-the-go shifts, made without interruption of power flow, and an increasing number of shifts.

The accompanying article discusses one of these new transmissions — the MF 65 hydraulically shifted transmission developed by Massey-Ferguson for farm tractors.

Future issues of the Journal will contain articles on the following heavy-duty transmissions:

- Twin Disc powershift transmission designed for off-highway trucks and self-propelled scrapers with engines up to 425-hp net rating.
- Caterpillar powershift transmission developed for track-type tractors, rubber-tired tractors, and the Traxcavator loader, which may be rubber tired or have tracks.

Tractor transmission with on-the-go shifts

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combination with an overrunning clutch of the sprag-type to provide the shift on-the-go. The hydraulic oil for actuating the clutch was supplied from a small gear-type pump, driven from the tractor power take-off shaft, and mounted on a bracket secured to the standard tractor draft control system hydraulic pump. Oil from this pump was supplied to a combination control valve and pressure-regulating unit contained in a small valve block mounted on the transmission input shaft bearing carrier. This control valve was actuated by a finger-tip control lever and mechanical control linkage extending through the top of the transmission housing.

The general arrangement is shown in Fig. 3, except that the sprag-type overrunning clutch has been replaced by a jaw-type unit.

The transmission housing is unchanged from the standard manually shifted transmission, except that two operations must be done after the transmission case is removed from the existing automated transfer plant.

The manually shifted sliding gears in the transmission, which provide the six basic sets of speeds and the planetary compounding unit at the rear of the transmission, are unchanged from the components used in the manually shifted transmission and on which field experience extending over 500,000 tractor units has been acquired.

Several prototype transmissions were built and an intensive field and laboratory test program begun. After several hundred hours of field test experience, erratic engagement was noted on the overrunning sprag clutch of one of the transmissions. The unit was disassembled and the sprags carefully examined. Wear was found on the profile of the sprags. A tentative diagnosis of inadequate lubrication was made, and the gear housing was modified to provide additional oil holes for improved lubrication. However, this incident raised a question as to the adequacy and durability of the sprag unit.

In order to establish the absolute magnitude of the torque peaks reaching the overrunning clutch more accurately, and also the nature of the torsional vibration in the drive train, a prototype transmission was instrumented with a strain gage torquemeter on the transmission input shaft. Strain gage oscillograph records were taken of the transmission input torque, both with the 3-cyl diesel engine used in the smaller Massey-Ferguson tractor and the 4-cyl engine used in the model 65 tractor. This investigation covered engine speeds of 1000-2000 rpm and loads ranging from the minimum output necessary to propel the tractor on concrete to the maximum output available from the engine. In addition, the transient conditions that occur at the moment the shift is made were also investigated. Representative sections from these oscillographs, for both steady-state and transient conditions, are shown in Figs. 4–8. These oscillographs show the continuity of power flow, and the smoothness of the shift obtained from the combination of the hydraulic clutch and the overrunning drive.

It was found from these tests that the sprag is subjected to cyclically varying engine torques from a low of 26 ft-lb to a maximum of 122 ft-lbs per cycle, and with a frequency of approximately 4000 cpm, or approximately twice the engine speed in revolutions per minute. As might be expected, the torque peaks match the firing impulses of the engine cylinders. Moreover, the rate of change of torque is very high.

This information made it necessary to reconsider the suitability of this type of overrunning clutch unit for this application.

It can be appreciated that this was a crucial point in the development of the transmission, since the entire approach to the problem of providing a smooth shift had been based on the use of an overrunning clutch unit. Moreover, space limitations within the housing precluded the possibility of using multiple wet clutch units. Careful analytical consideration was give to various other forms of overrunning clutch units, including the ramp and roller configuration and ball and ramp combinations. However, all of these configurations suffer from the same basic drawback as the original sprag unit. That is, the torque is transmitted by virtue of high surface compressive stresses between curved surfaces, obtained by a wedging action. The high cyclical variation in torque, and high frequency of these variations as revealed by the oscillograph records, made it seem probable that these units would suffer from the same problems as the sprag-type clutch — possibly to a still higher degree.

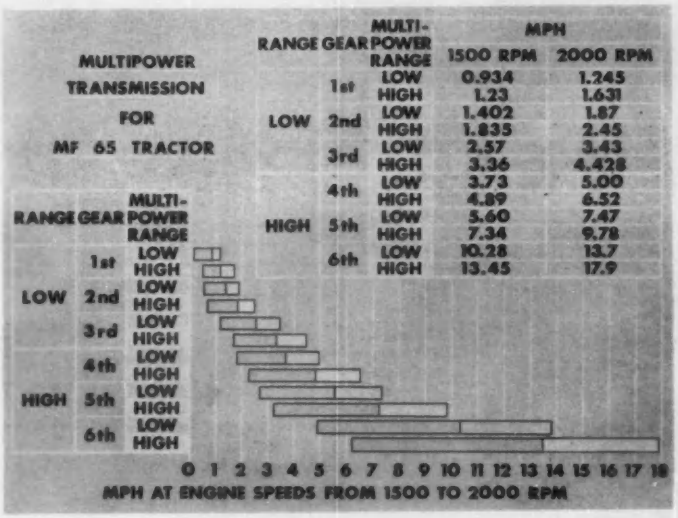
Change to jaw-type overrunning clutch

The only practical solution appeared to be an overrunning clutch that, when locked up, transmitted the torque by means of the positive locking action of jaw teeth rather than by a wedging action on balls or rollers and whole engagement characteristics were such that it would be unaffected by relatively high-frequency torsional vibrations through the drive train. A device meeting these requirements was developed by adaptation and modification of the familiar jaw-type overrunning clutch.

The combination of such a coupling, a spring constantly urging it into engagement, and a helical spline results in an overrunning clutch with the feature of automatic lockup when the speed of the driving member and the coupling are synchronized. This arrangement is shown in detail in Fig. 9, along with diagrams showing the sequence of events that occur as the coupling is first disengaged from the lockup position and then overruns or freewheels.

The coupling is subjected to a continuous bouncing or oscillating motion along its axis as it is urged into engagement by the spring and repelled by the contact with the angular faces of the mating teeth on the driving gear. Because of the relatively low inertia of the coupling and of the light spring force required, the forces involved are not large, nor is the resultant noise objectionable. In fact, when installed in the tractor, the overrunning coupling is just barely audible when the engine is at idle.

It is apparent that this coupling overcomes the



RANGE	GEAR	MULTI-POWER RANGE	MPH 1500 RPM	MPH 2000 RPM
LOW	1st	LOW	0.934	1.245
		HIGH	1.23	1.631
	2nd	LOW	1.402	1.87
		HIGH	1.835	2.45
	3rd	LOW	2.57	3.43
		HIGH	3.36	4.428
	4th	LOW	3.73	5.00
		HIGH	4.89	6.52
HIGH	5th	LOW	5.60	7.47
		HIGH	7.34	9.78
	6th	LOW	10.28	13.7
		HIGH	13.45	17.9

Fig. 1 — MF 65 Multipower transmission allows shifts to be made, while the tractor is in motion, between pairs of speeds in each of its six manually selected gear speeds.

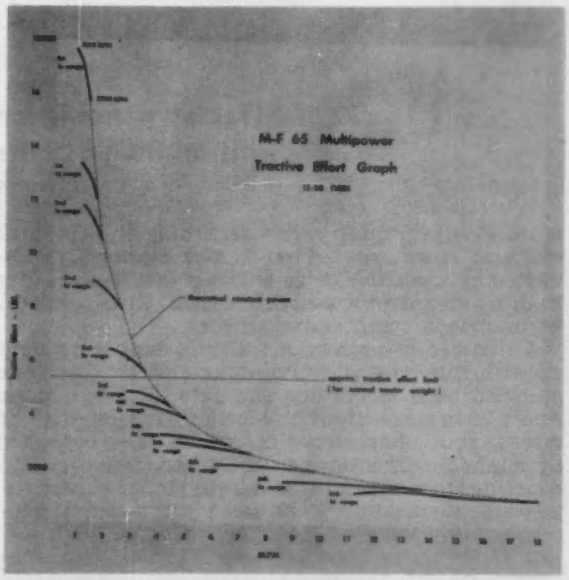


Fig. 2 — Curve of theoretical tractor effort in each gear versus theoretical maximum obtainable with an infinitely variable transmission. Note that there is a reasonable approximation to full utilization of available engine power over the full speed range.

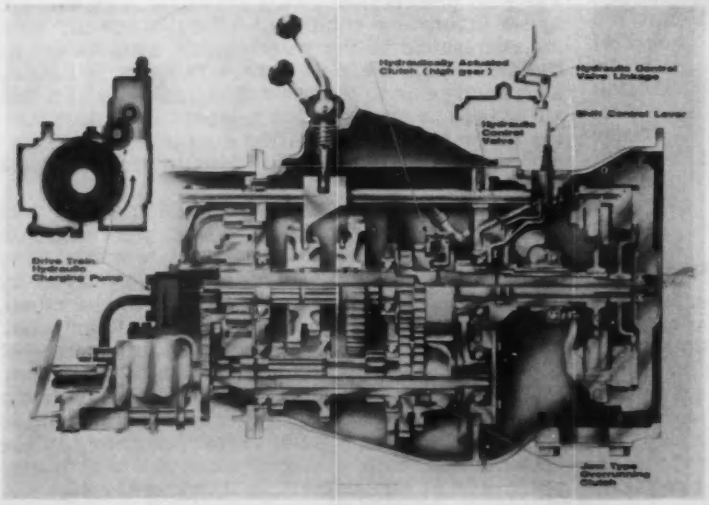


Fig. 3 — Multipower transmission.

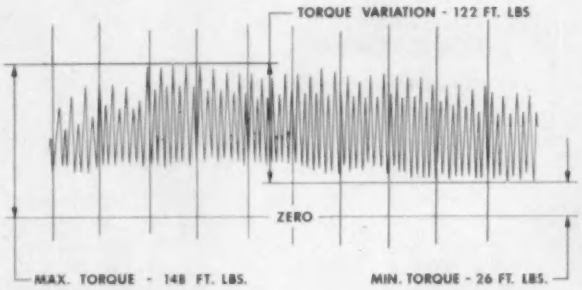


Fig. 4 — Steady-state variation in transmission input torque at half engine load.

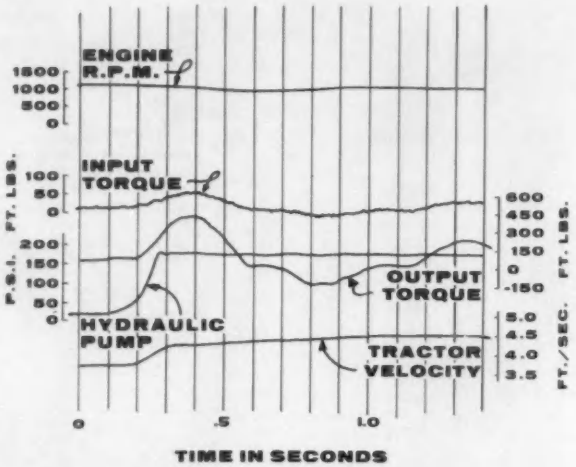


Fig. 5 — Low-high shift at no load and 1200 engine rpm.

Tractor transmission with on-the-go shifts

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objections previously noted regarding the sprag or ball and ramp type. That is, the torque is transmitted by a positive drive between jaw teeth rather than by means of a wedging action, with resultant high surface compressive stresses.

A number of prototype transmissions were built up with this type of overrunning clutch. The tests included both laboratory and extensive field work. Apart from some slight difficulty with engaging and disengaging characteristics, which was corrected by minor modifications to the tooth geometry, the couplings performed satisfactorily under exceptionally arduous field test conditions. To accelerate the tests, the number of shifts between the high and low range of the transmission was increased to approximately 1½ times per minute. Obviously, this is far in excess of what would be encountered in any normal field usage, but the large number of engagement and disengagement cycles on both the coupling and the hydraulically actuated wet clutch permitted an accelerated evaluation of the durability of the various drive train components. These periods of high frequency of shift under heavy load were alternated with periods of more normal usage in the field.

Need to lower transmission oil temperature

This portion of the test program indicated that the additional heat input to the transmission from the hydraulic charging pump for the Multipower transmission was resulting in an increase in transmission oil temperature over the standard transmission under the same operating conditions. It is apparent that this heat input is a maximum when the transmission is operating in high range; that is, with the hydraulically actuated clutch engaged, since under this condition the hydraulic pump is delivering its full flow against a constant pressure established by a pressure-regulating valve in the circuit. Fig. 10 shows a schematic diagram of the hydraulic circuit.

It is relatively easy to deal with this additional heat load by means of an external oil cooler, but such a solution is expensive and requires the additional complication of external hydraulic lines, which are always undesirable. Therefore, an attempt was made to modify the system to reduce the additional heat input to the transmission without compromising the performance of the unit. A transmission was set up in the laboratory and motored from the input side by a d-c dynamometer, which permitted input speed and torque to be established. The output shaft was connected to a second dynamometer. In this fashion, power losses in the transmission at various speeds and load levels, both with and without the charging pump in the circuit, were established. In addition, the stabilized transmission oil temperature for various ambients was also determined. This stabilized temperature under laboratory conditions of quiescent air does not correspond to the transmission temperature in the tractor in the field, where radiator fan blast, air velocity due to tractor motion, and the like, will all affect the transmission temperature. However, the laboratory determination does permit the comparison of various configurations under controlled conditions.

Concurrently with the transmission power loss investigation, separate power checks were made on a small dynamometer on the hydraulic pump. The delivery of the pump was reduced progressively by reducing the face width of the gears in the pump, until field experience indicated that a safe limit had been reached for adequate speed of engagment of the hydraulic clutch. This reduction in pump flow, plus minor modifications to the details of the pump construction, reduced the power loss of the pump to the level shown in Fig. 11. Total power loss in the transmission, both with and without the hydraulic pump, and at various loads, is shown in Fig. 12.

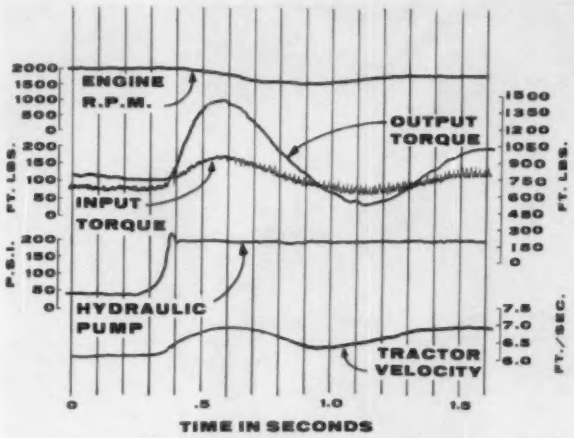

Fig. 6 — Low-high shift at full load and 2000 engine rpm.

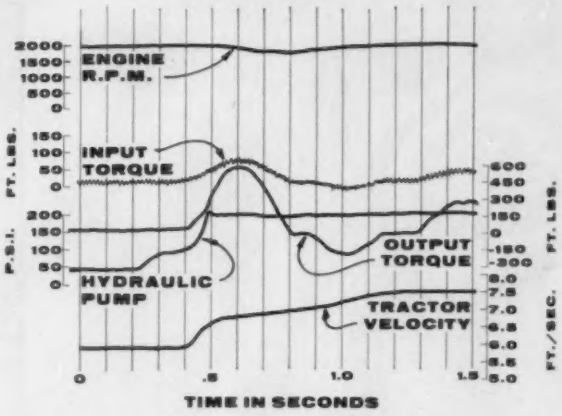

Fig. 7 — Low-high shift at no load and 2000 engine rpm.

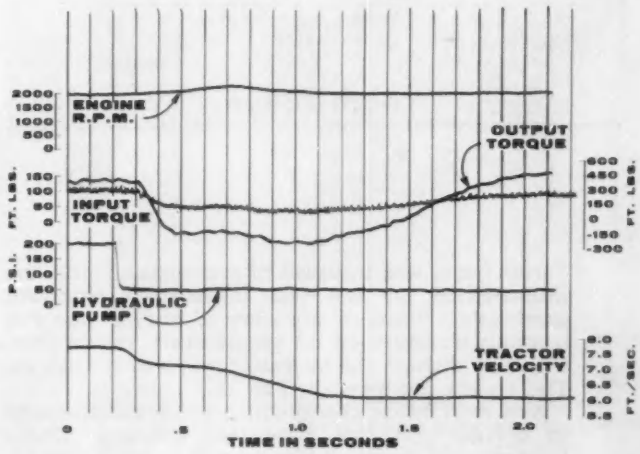

Fig. 8 — High-low shift at full load and 2000 engine rpm.

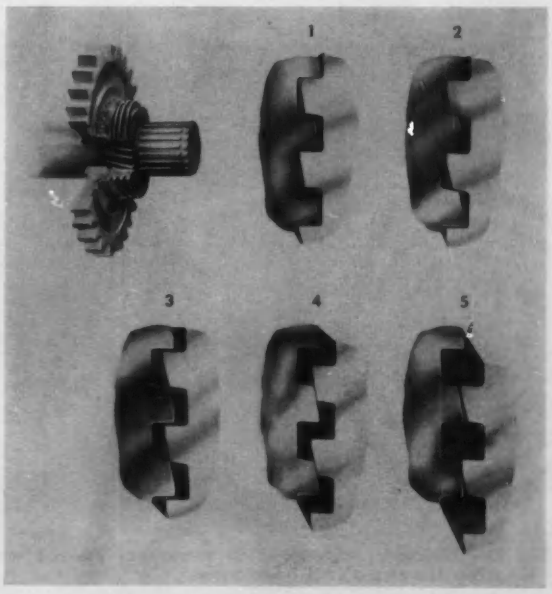

Fig. 9 — Jaw type of overrunning clutch. Diagrams show sequence of events that occur as coupling is first disengaged from lockup position and then overruns or freewheels.

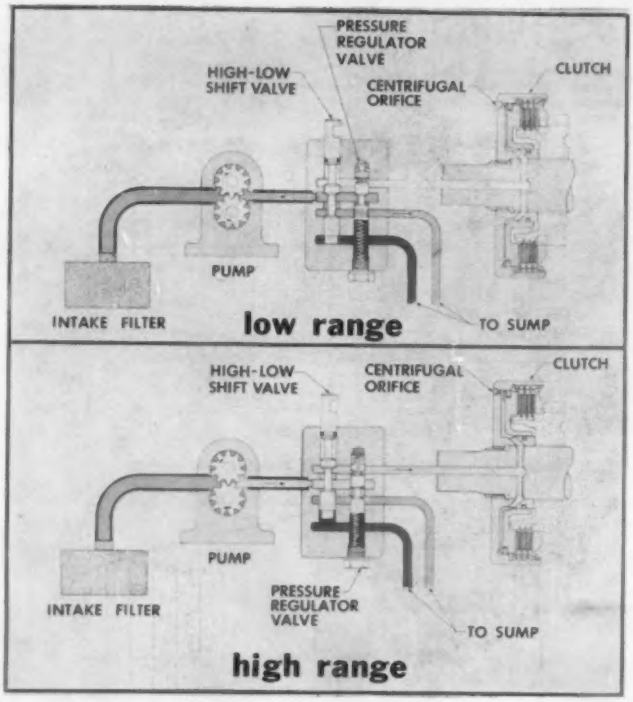

Fig. 10 — Multipower hydraulic circuit diagram.

Tractor transmission with on-the-go shifts

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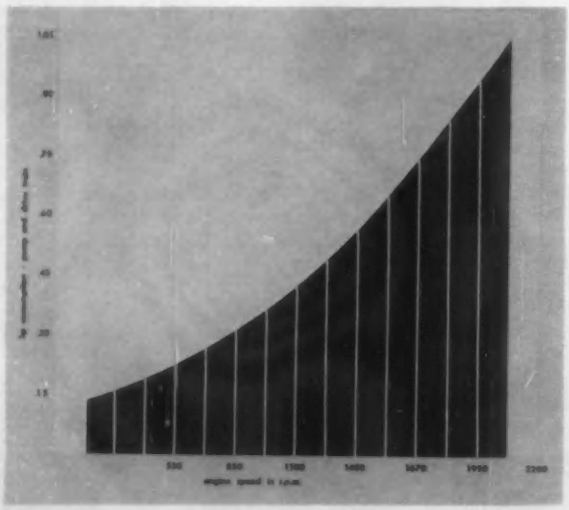


Fig. 11 — Horsepower consumption of transmission charging pump (200-psi constant pressure, 185 F temperature).

This pump was installed in combination with the transmission on the test installation described previously. Then, a final set of curves was run showing transmission oil temperature versus time, with and without the hydraulic pump in the circuit. The results are given in Fig. 13.

As a final check, the modified pump was installed in several prototype field test tractors. These tractors were operated side by side in the field with standard tractors having the same engine and equipped with the same implements. Engine load and speed were controlled on the test units to the closest limits practical. The tractors were operated around a square course so as to minimize or eliminate the effect of wind velocity or direction. This test indicated a final stabilized oil temperature on the Multipower transmission, operating continuously in high range, to be approximately 30 deg above that of a standard tractor operating under the same conditions. This result is in general agreement with the laboratory findings. Moreover, the installation of thermocouples at positions corresponding to the operator's foot, shin, and knee showed that this increased transmission oil temperature resulted in an increased temperature at these points of the operator's anatomy of only 3–5 deg.

Field evaluation by a large number of operators indicated that, subjectively, there was no important difference in operator comfort.

Fig. 14 shows the power flow in the transmission.

To Order Paper No. 391A . . .
from which material for this article was drawn, see p. 6.

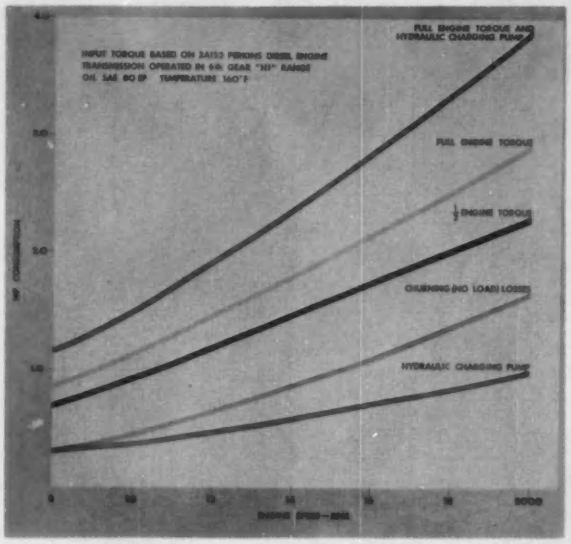

FULL ENGINE TORQUE AND HYDRAULIC CHARGING PUMP
FULL ENGINE TORQUE
½ ENGINE TORQUE
CRUISING (NO LOAD) LOSSES
HYDRAULIC CHARGING PUMP

Fig. 12 — Multipower transmission horsepower consumption.

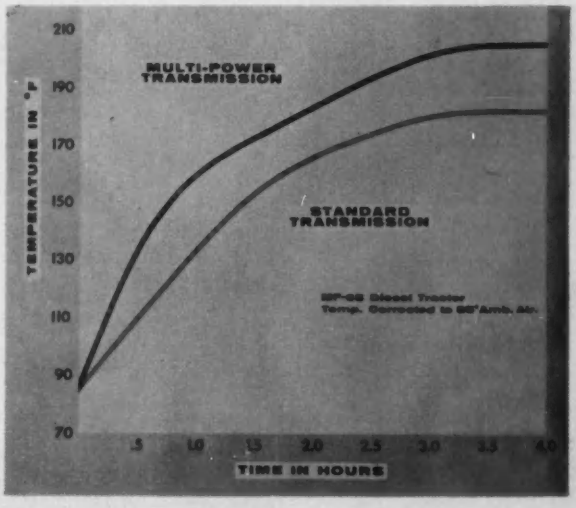


Fig. 13 — Comparison of temperatures recorded in Multipower transmission and standard transmission.

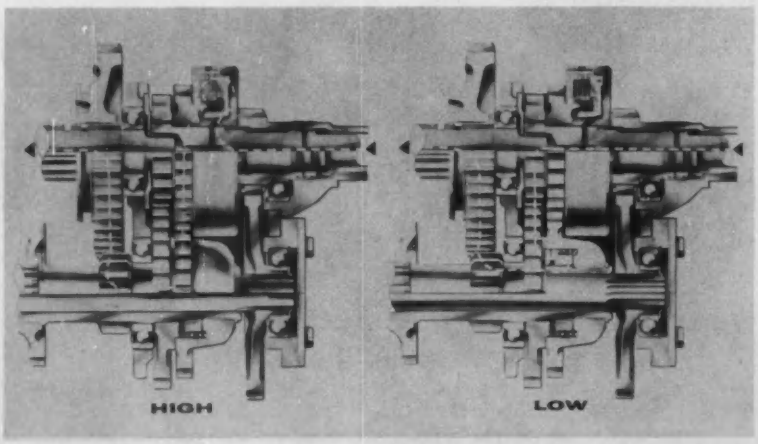
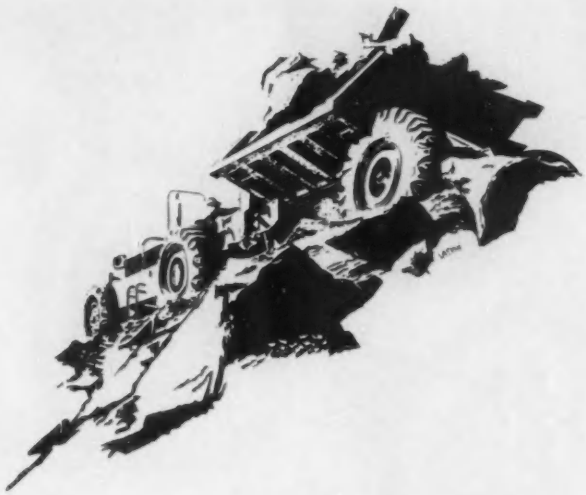


Fig. 14 — Power flow in Multipower transmission.



Oliver's new "1800"

. . . designed to make best possible

Excerpts from paper by

T. H. Morrell and K. S. Minard

Oliver Corp.

OLIVER'S new 1800 gasoline engine is the result of applying to our basic Super 88 gasoline engine the concepts developed on the XO-121 engine — a 12/1 compression ratio experimental engine, which gave exceptional performance and fuel economy.

Two-piece cylinder head

For our development work, we decided to apply a new cylinder head of two-piece construction with an XO-type combustion chamber to the Super 88 engine. We had been experimenting for some time with two-piece cylinder-head designs and had accumulated considerable field experience with several hundred two-piece heads on the Super 88 and other models.

The design consists of a main lower cylinder-head casting with a separate cover casting, as shown in Fig. 1. The mating surfaces of the head body and cover are first machined, then assembled with a gasket between them. The remainder of the machining is accomplished as if the head was of one-piece construction. The benefits derived from such a design are:

1. Easier to cast.

2. Reduced dry sand core weight.

3. Reduced casting scrap from core shift or blowholes.

4. Easier to clean.

5. Elimination of cooling restrictions by removing all fins, core wires, and core sand.

6. Easier to inspect and determine if casting is sound prior to machining.

The adaptation of the two-piece construction is desirable for more consistent cooling to permit maximum performance from a high-compression engine.

Compression ratio study

The first step in the development of this new engine was to evaluate the performance of the XO-type combustion chamber at various compression ratios and compare this performance to the yardstick previously established by the XO-121 engine studies. To accomplish this, cylinder heads were

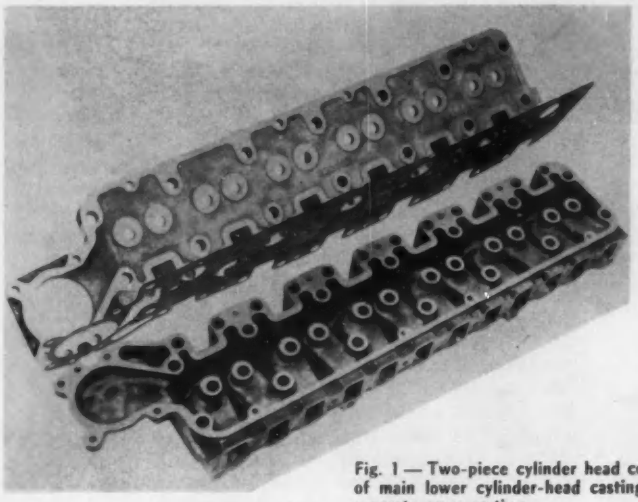


Fig. 1 — Two-piece cylinder head consists of main lower cylinder-head casting with separate cover casting.

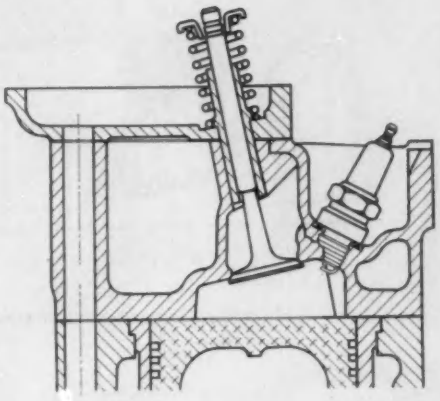


Fig. 2 — Cylinder head with 7/1 compression ratio.

tractor engine

use of available fuels.

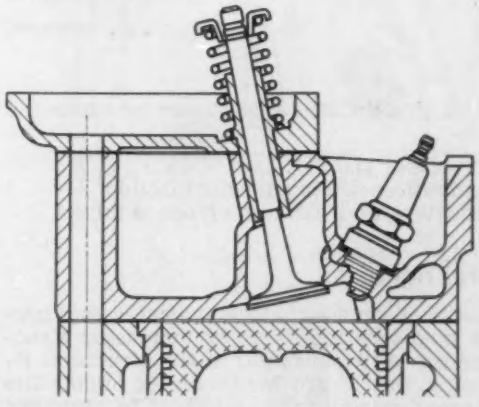


Fig. 3 — Cylinder head with 12/1 compression ratio.

provided with compression ratios of 7.0, 8.0, 9.5, and 12.0/1. Figs. 2 and 3 show cross-sections of the 7/1 and 12/1 cylinder heads. Intermediate compression ratios were obtained by varying the depth of combustion chamber. The 18-mm spark plugs were located on the left side of the engine between external (nonwater jacketed) exhaust ports. The valves and roof of the chamber were placed at a 12-deg angle.

Fig. 4 shows the performance of this engine with the XO-type head at various compression ratios and the performance of the XO-121 at the same ratios. To eliminate the adverse effect of detonation on performance, special nonknocking high-octane fuel was used for this comparison. Although the Super 88 showed acceptable performance at the various ratios and response to changes in ratio, the results were not as good as our previously established XO-121 "yardstick." This is noted by the higher brake mean effective pressure and lower specific fuel consumption of the XO-121 at each compression ratio. These results illustrate that design principles employed on one engine do not necessarily hold true on another engine with a different design configuration. It became evident that additional refinement would be required to secure peak performance.

This further development of the Super 88 engine

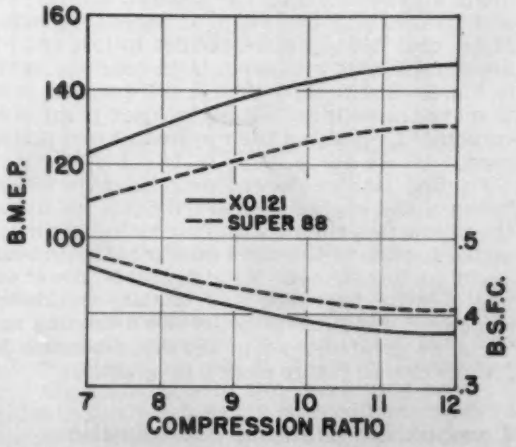


Fig. 4 — Performance comparison of XO-121 engine and Super 88 engine at 1600 rpm, without fan.

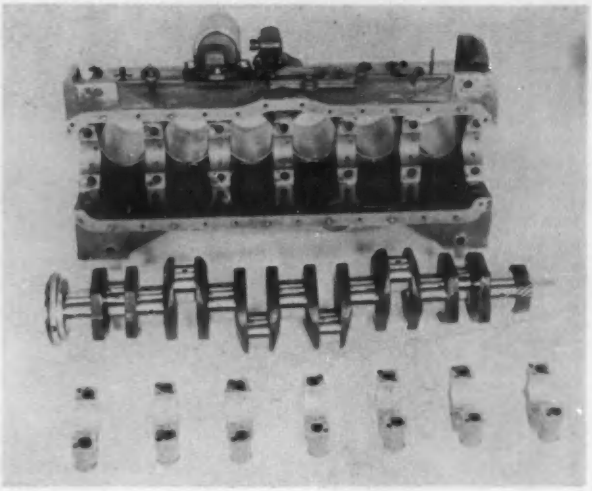


Fig. 5 — Crankshaft with seven main bearings.

Oliver's new "1800" tractor engine

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was resolved into the following phases for additional studies:

1. Structural rigidity.
2. Combustion-chamber configuration.
3. Induction and exhaust system analysis.

Structural rigidity

The results of some early tests indicated that performance might be improved by increasing structural rigidity. A prime factor in the structural rigidity studies was to provide increased engine life through great durability, in addition to improved efficiency and low cost of operation. Since we were carrying out a parallel future diesel program, which might also benefit from increased structural rigidity, and considering operation at speeds considerably faster than 1600 rpm, we decided to test and evaluate a crankshaft with seven main bearings, as shown in Fig. 5. At the same time, a full-pressure lubrication system with high-capacity gear pump was incorporated, replacing the metered system previously used.

Friction studies showed no noticeable difference between the engine with seven main bearings and the production engine with four main bearings. Any added friction of the three additional main bearings could not be detected. At high speeds, power output was slightly improved and engine operation was somewhat smoother with the seven-bearing engine. Thus, we decided to adopt the seven-bearing design for our overall future engine program.

Combustion-chamber configuration

The next step was to concentrate on combustion-chamber configuration and to develop a high-ratio chamber, which would provide maximum power and economy using regular gasoline. For this study, the 8.0/1 compression ratio head was selected.

We felt that performance could be improved by increasing the amount of turbulence in the chamber through improved squish action. There appeared to be a "dead area" at the shallow end of the chamber, especially at lower compression ratios. The first attempt to correct this problem was to bevel the back wall of the chamber at a 45-deg angle, as shown in Fig. 6. The results of this modification were disappointing, indicating a performance loss of approximately two horsepower, apparently due to a reduction in the squish area.

Squish height (distance from piston to cylinder head) was also investigated, and the optimum height was determined to be 0.040–0.060 in. The squish path was very important to concentrate the fuel-air mixture in the spark-plug area. When spark plugs were evaluated, the projected-nose type was found to provide a slightly flatter spark traverse curve with better power at retarded spark settings. These results held true in additional developments.

The next attempt to improve turbulence was to reduce the depth of the combustion chamber by using the 9.5/1 ratio cylinder head and placing the remainder of the combustion-chamber volume in the piston to obtain an overall ratio of 8.0/1. This combination is shown in Fig. 7. This design, called the "concave piston," provided a more compact chamber, locating the spark plug closer to the squish path.

Cooling was improved in this step, as compared to the designs shown in Figs. 2, 3, and 6. The compression rings were changed to a deeper section and moved down so that the top ring did not traverse above the water jacket. This reduced the temperatures in the ring belt, thereby providing longer ring and piston life.

Another combustion-chamber configuration called the "wedge or hump piston" was also tested at 8.0/1 ratio. As shown in Fig. 8, this consisted in machining the roof of the combustion chamber and providing a matching wedge or hump on the top of the

piston. A portion of the combustion-chamber volume was provided by lowering the flat deck of the piston approximately 3/16 in. below the top of the sleeve. We believed that this design, while still retaining a compact chamber, might improve performance by directing the squish directly past the valves to the spark plug, thus creating better turbulence and scavenging in the spark-plug area.

To evaluate fully the performance of these chambers with fuels of different octane ratings for comparison with the flat-piston design, the knock-rating procedure previously developed by Ethyl Corp. was employed. Basically, this procedure involves the following three steps:

1. Running a series of spark traverse curves at various speeds, using a special high-octane development fuel to prevent knock. The development fuel is similar to a regular-grade gasoline in all respects except octane number. The carburetor is adjusted to deliver the final calibration air/fuel ratio at each speed. The runs provide power and specific fuel consumption data for spark timings ranging from greatly retarded to beyond maximum power without interference from knock.

2. Determining knock-limited spark timings at various speeds on two series of special full-boiling, commercial-type reference fuels. The fuels in one series have zero sensitivity, whereas those in the other have a sensitivity of 10. Motor octane numbers range from 72 to 87 in 5-octane increments in each series. Thus, the fuels range from 72 Motor-72 Research, to 87 Motor-97 Research. The knock-limited spark timing is that required to produce a barely audible knock (commonly called trace or borderline knock). The same air/fuel ratios used during spark traverse tests on development fuel are maintained during the knock tests.

3. Interpolating between reference fuels to determine spark timings for borderline knock on fuels of any desired octane number and sensitivity, and then finding the corresponding power and specific fuel consumption data from the spark traverse curves.

For our analysis of the three combustion chambers, we selected the following three hypothetical fuels:

Low	80.5 Motor, 88.5 Research
Average	83.0 Motor, 91.5 Research
High	86.0 Motor, 95.0 Research

The borderline knock-limited performances of the three combustion chambers with these hypothetical fuels are shown in Figs. 9, 10, and 11. In these tests, the concave piston design provided superior performance with all three fuels, indicating good fuel utilization regardless of fuel quality. Although the wedge piston did not perform well with low-quality fuel, its performance improved at a greater rate than that of the other chambers when higher quality fuels were used. Data were not taken at speeds above 2200 rpm, but the results indicated that the wedge piston might perform quite well at higher speeds. Some trouble was encountered with the wedge pistons, due to a hot spot at the top of the wedge. This hot spot, which caused preignition, was reduced but not entirely eliminated by redesign of the underhead of the piston.

An evaluation of the data obtained to this point indicated a possibility of reverse squish between the piston and head underneath the spark plug. This reverse squish appeared to counteract the main squish from the other side of the piston, thereby reducing the turbulence in the spark-plug area. To investigate this possibility, a new cylinder head was designed, as shown in Fig. 12. In this design, the valves were placed at an 11-deg angle instead of 12

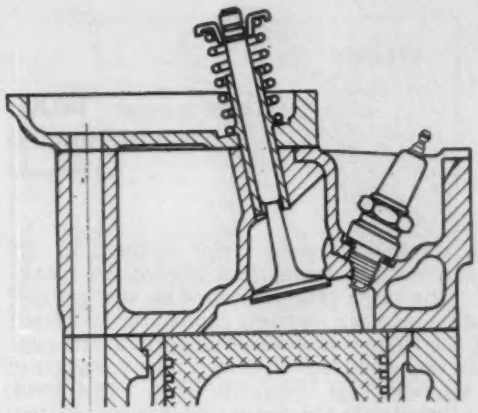


Fig. 6 — Beveled-back combustion chamber with 8/1 compression ratio.

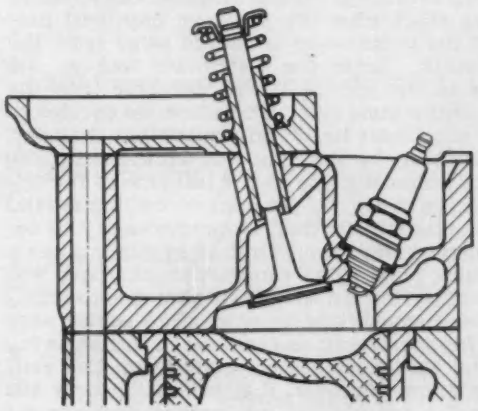


Fig. 7 — Concave piston design.

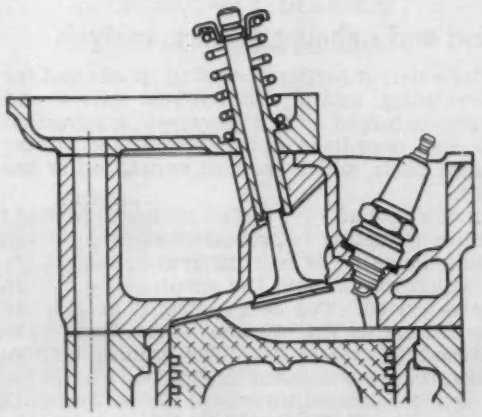


Fig. 8 — Wedge piston design.

deg to obtain better rocker arm action, and the combustion chamber was shifted toward the spark-plug side. The spark plug remained on the left side of the engine between exposed (nonwater jacketed) ports, but the ledge connecting the ports at the edge of the head was removed to prevent accumulation of dirt and trash around the spark plug. This head, which was tested with the flat piston, appeared equal to or slightly better than the previous flat-piston designs.

It became evident at various stages of the development that spark-plug life could be improved materially if the plugs could be moved away from the exhaust ports. Since the distributor was on the right side of the engine, it was desirable that the plugs be on the same side. Therefore, we decided to reverse the cylinder head and combustion chamber, placing the plugs on the right side while leaving the intake and exhaust ports on the left side of the engine, as shown in Fig. 13. To improve cooling around the spark plug still further, it was necessary to decrease the plug size from 18 mm to 14 mm and use a ¾ in. reach plug. The combustion chamber was shifted farther toward the spark-plug side to eliminate reverse squish and to gain more squish area opposite the spark plug, as can be seen in comparing Figs. 7 and 13. Since the concave piston had continued to show improved fuel utilization over the wedge or flat-top pistons, all further development was continued with the concave design.

Induction and exhaust system analysis

In anticipation of higher operating speeds and for better breathing, intake and exhaust valves and ports were enlarged. The reversed combustion chamber also permitted more streamlined intake and exhaust ports, which reduced restriction of the intake air.

Studies of camshafts for higher speeds were made to determine if further improvements were possible. We evaluated a series of five different camshaft designs in which the lift and the opening and closing events were varied. The best camshaft design had the same timing as the original Super 88, but approximately 17% greater lift. The profiles of these two camshafts are compared in Fig. 14. Fig. 15 indicates considerable improvement in performance with the new high-lift camshaft throughout the speed range. To determine the necessary ramp design for this cam, a Lashograph was employed to determine lash loss under all conditions of operation. This was an optical device (obtained from Ethyl Corp.) which visually indicates valve lash during operation.

Manifold investigations were conducted throughout the entire development program, with various designs being tested. The original exhaust mani-

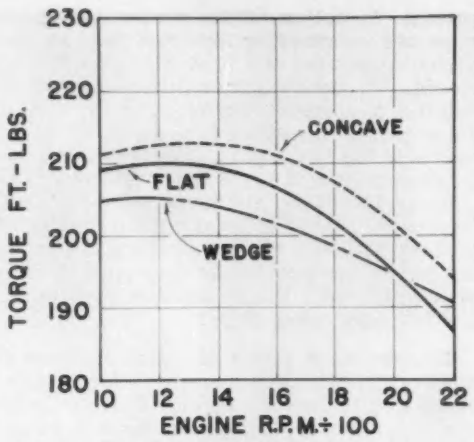


Fig. 9 — Borderline knock-limited torque with low hypothetical fuel (8/1 compression ratio).

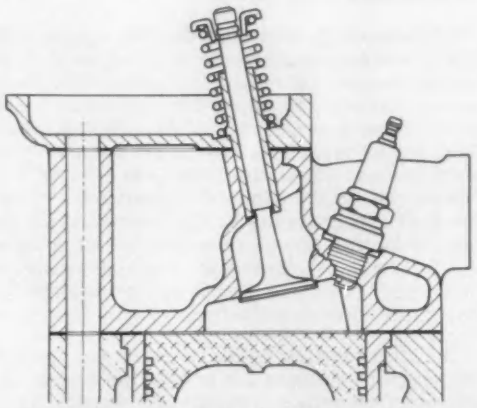


Fig. 12 — Revised head with valves placed at 11-deg angle instead of 12 deg — to give better rocker arm section.

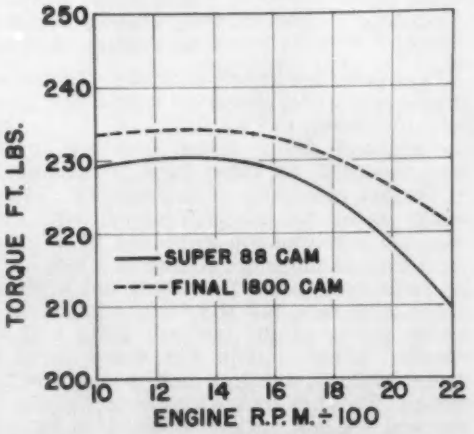


Fig. 15 — Camshaft performance comparison with nonknocking fuel.

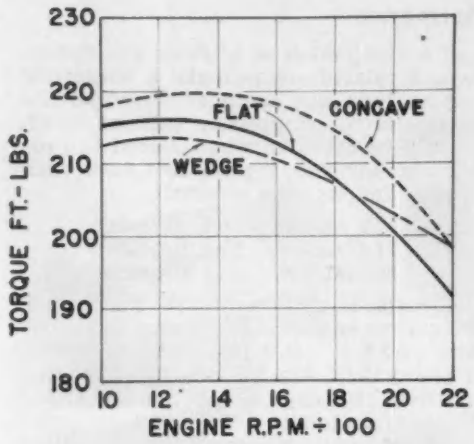


Fig. 10 — Borderline knock-limited torque with average hypothetical fuel (8/1 compression ratio).

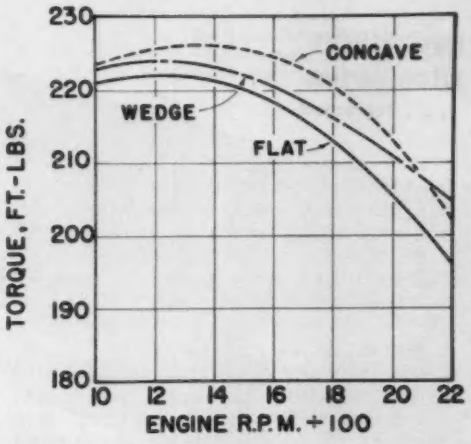


Fig. 11 — Borderline knock-limited torque with high hypothetical fuel (8/1 compression ratio).

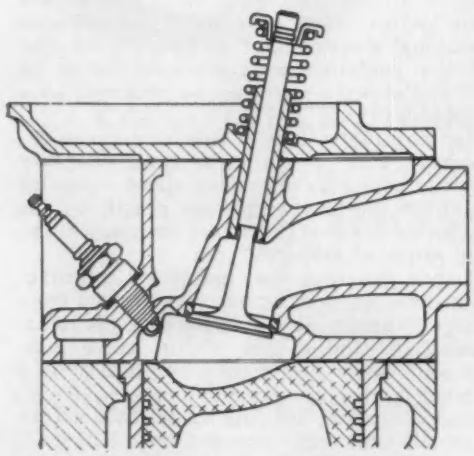


Fig. 13 — Final head and piston design.

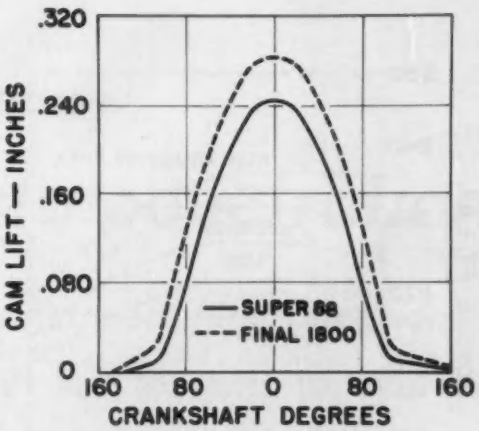


Fig. 14 — Intake cam profile comparison.

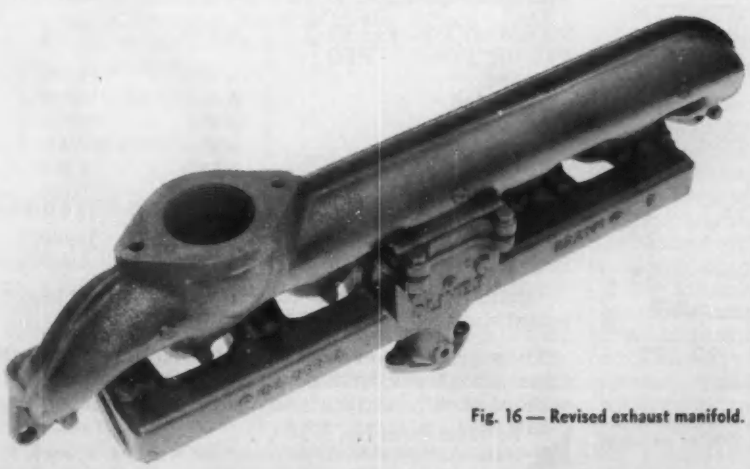


Fig. 16 — Revised exhaust manifold.

fold connected to cylinder-head exhaust ports that were not water jacketed presented a warpage problem, which was reduced by reversing the head and jacketing the exhaust ports. Further improvements in the exhaust manifold were made by using a special high-strength low-growth cast-iron alloy, increasing the runner size by 25% and providing ribbing, as shown in Fig. 16.

The intake-manifold investigations involved determination of riser and runner size, manifold shape, placement and amount of manifold heating, and riser length. In the final design, heat was applied to the top of the T section above the riser, and a rectangular runner was employed to reduce any tendency for fuel to centrifuge out of the mixture. Individual porting of each cylinder was incorporated.

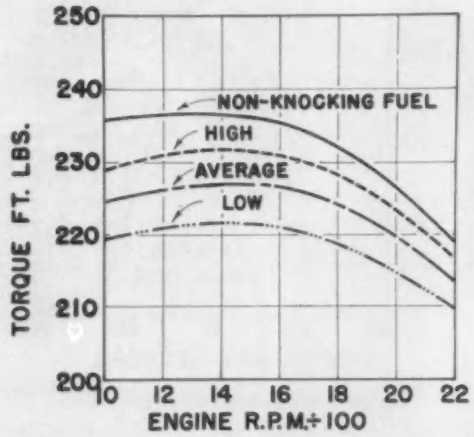


Fig. 17 — Borderline knock-limited torque with anticipated 1961 regular-grade fuels.

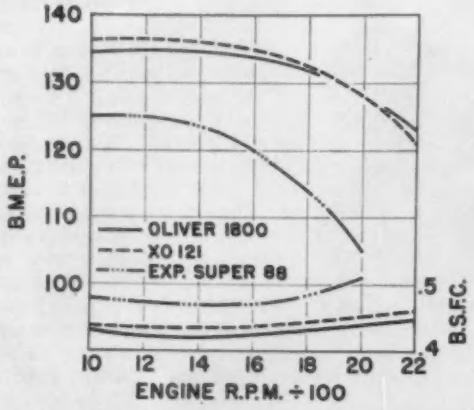


Fig. 18 — Final performance comparison with standard accessories — carburetor adjusted to give 97% of maximum power.

Final performance

Following the completion of work on the induction system and related components, a borderline knock-rating analysis was again employed to determine the maximum compression ratio at which the engine could be operated when placed in production. For this analysis, typical 1961 fuels with octane ratings as follows were selected:

Low	82.5 Motor,	90.5 Research
Average	84.0 Motor,	92.5 Research
High	85.5 Motor,	94.5 Research

With these fuels, it was found that the engine developed maximum knock-limited power at a compression ratio of 8.5/1. This ratio was, therefore, selected for production. Fig. 17 shows the performance of the Oliver 1800 engine at borderline knock with these three typical fuels.

A comparison of final performance of the Oliver 1800 gasoline engine as released for production with the original XO-121 engine and the Super 88 with the XO-type combustion chamber (all at 8.5/1 compression ratio) is shown in Fig. 18. These curves indicate the performance improvements obtained by the additional development of this engine and show that the performance goals established by the XO-121 at the same ratio can be obtained on a production engine.

One of the main objectives of this long-range research program was to maintain good economy throughout the complete operating speed range of the engine. The results were very gratifying, as evidenced by the relatively flat fuel economy curve in the speed range of 1000–2200 rpm.

This research program also permitted improvements in our diesel engines which were derived from the two-piece cylinder head and studies of manifolding, camshaft timing and profile, valve lash, lubrication and other design characteristics of a minor nature.

On Nebraska Test No. 766, the model 1800 established a new all-time fuel economy record of 0.472 lb/hp-hr or 13.18 hp-hr/gal on the maximum-power power-take-off test. Under the current test procedure (instituted in 1959), the following fuel economies were obtained:

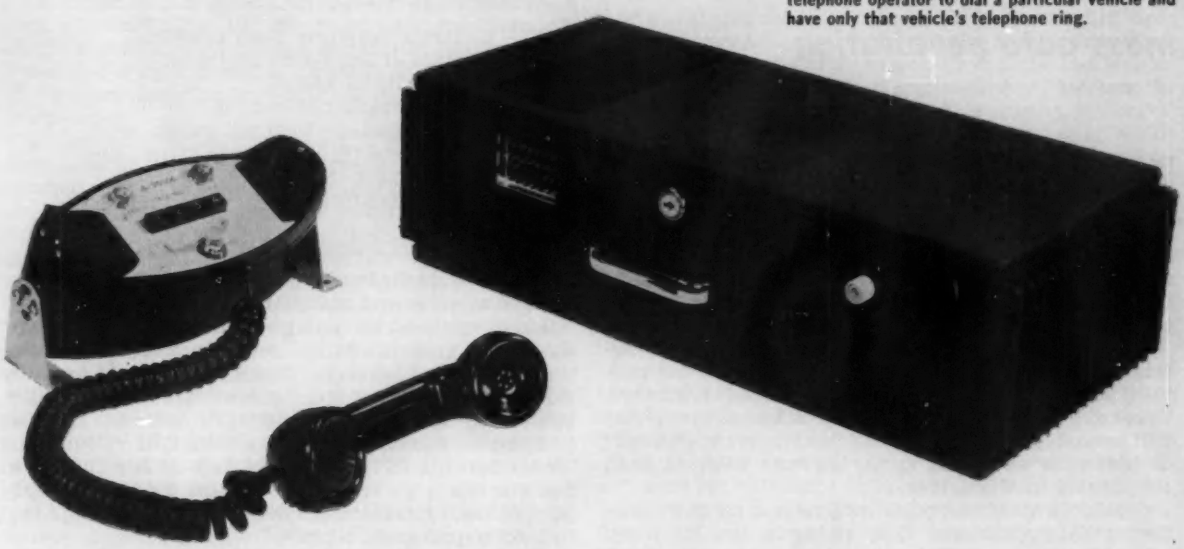
Test Description	Fuel Economy Lb/hp-hr	Hp-hr/gal
Maximum Power — PTO	0.472[a]	13.18[a]
Varying Power — PTO		
Rated	0.481[a]	12.93[a]
½ Rated	0.651[a]	9.56[a]
Maximum	0.474	13.14[a]
¼ Rated	0.971[a]	6.41[a]
¾ Rated	0.527[a]	11.80[a]
Average	0.590[a]	10.55[a]
Maximum Drawbar Power	0.532[a]	11.71[a]
75% Pull Drawbar	0.566	10.99[a]
50% Pull Drawbar	0.688	9.04[a]

[a] Denotes new record for current test procedure established by Test No. 766.

These records were established, despite a governed speed of 2000 rpm with power-consuming accessories such as power steering and hydraulic pumps.

To Order Paper No. 395B . . .
from which material for this article was drawn, see p. 6.

Fig. 1 — AChieverfone vehicle telephone permits telephone operator to dial a particular vehicle and have only that vehicle's telephone ring.



Electronics industry gears for ***mass auto penetration***

driverless vehicles . . . glove-compartment telephones . . . collision-proof highways . . . all are forecast for the 1970's.

Based on paper by

Arthur J. Runft
AC Spark Plug

ELECTRONICS are expected to find increasing application to motor vehicles in the future. Looking ahead to the 1970's, three general areas appear unusually attractive:

1. Guidance and control.
2. Safety.
3. Communications.

Guidance and control

The potential of electronics for guiding and controlling vehicles is immense. Radio, radar, modulated light, and inertial guidance systems could be used.

Electronics could replace the toil of the Kansas wheat farmer by directing tractor, planter, plow, or combine back and forth across vast acreages to sow and reap his grain. It is technically feasible to establish such routine parallel paths of motion with electromagnetic or inertial techniques and automatically guide an unmanned machine along them. Turns at the end of a row or more complicated maneuvers could be achieved by using a two-dimensional programming computer.

Under development today are large, automatically guided mining vehicles which will traverse remote river-bed areas of Bolivia to carry out tin ore. At these rivers they will be automatically loaded with silt which contains the tin ore. Loading will be started by special controls which detect when the silt is sufficiently deep for proper operation. When the ore carrier is filled, it will automatically travel many miles back to the mill and civilization. The entire process of loading, hauling, and unloading will be accomplished without manpower.

Is it preposterous to envision a fully automated coal mine where automatic vein detection, digging, and loading puts coal in cars which are guided to the surface for conversion to low cost electric power?

Fully automatic earthmovers or road graders may take their place in the construction and maintenance of tomorrow's roads. Guidance could be accomplished by electromagnetic radiation or inertial systems. Today, tilt of the blade can be servoed to any desired angle by referencing it to a pendulous unit to detect vertical position. Location of a surface generated by the cutting blade could be controlled by establishing a radio wave plane in space

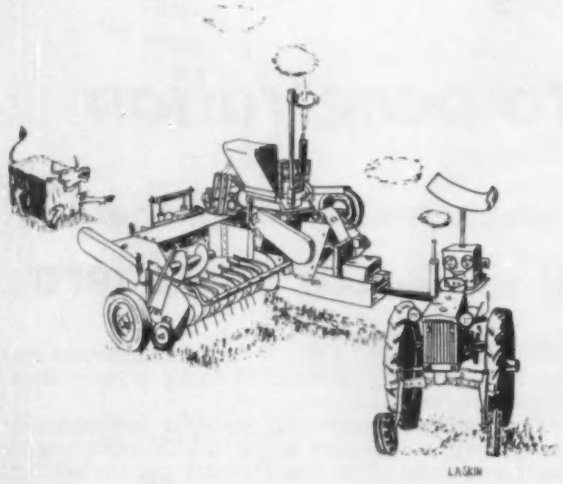
mass auto penetration

. . . continued

parallel to and a few feet above the desired cut. An antenna affixed to the top of the grader or dozer passing through this radio plane could detect deviations above and below it. As the machine moved along its path, these antenna signals could then servo the blade up and down in height to cut a surface exactly parallel to the radio plane at a predetermined distance below it.

Perhaps even greater potential exists for electronic guidance and control of vehicles whose motion is confined to specifically defined roadways. Trucks, buses, automobiles, and other conveyances will probably travel down the "electronic highways" of tomorrow at speeds up to 150 mph without need for control by the driver.

Guidance devices could assume one or more different configurations. For example, an electrical



Electronics promise driverless tractors to pull hay balers, plows, planters, and other farm machines.

cable buried beneath the road surface could transmit signals to coils on the vehicle to guide it along the cable path. This method is currently being investigated in the GM Research "Auto-Control System."

An alternate method of providing lateral guidance could be achieved by using trough-shaped roadways or ones with parallel retaining walls. Side-looking proximity devices could keep the vehicle in the middle of the road at all times.

A third scheme for guidance might transmit steering information to passing vehicles from antennas located beside the highway.

With any of these guidance systems, more sophisticated information than simple left-right lateral signals will have to be considered. Before proper signals can be applied to the steering gear, accelerator, and brakes, a small computer in the vehicle will have to operate on such inputs as:

1. Deviation from road center.
2. Rate of change of deviation.
3. Velocity of vehicle.
4. Acceleration of vehicle.
5. Anticipated turning rates, and the velocity and acceleration required for the turn.
6. Road conditions.
7. Wind.
8. Spring suspension characteristics.

Computer techniques of this type are being applied to missiles and many aircraft today.

Some inputs to the computer will come from outside of the vehicle and will be a function of its position along the highway. These inputs could be provided by modulating the signals transmitted to the vehicle by tones, phase shifts, or pulses. Typical commands conveyed to the automobile might be: "Start turning left 400 ft from now at the rate of 5 deg per sec," or "Immediately slow down at 5 mph per sec until you reach a velocity of 20 mph preparatory to stopping at toll gate."

The typical automobile of tomorrow will probably assume a dual functional role. In one mode of operation, it will be driven on conventional roads much as it is today. In the other mode, the car may take on a guidance attachment and an auxiliary propulsion device so that it may automatically travel on the "electronic highways" at very high, fixed speeds with controlled intervals between cars moving in the same direction.

Safety

Like guidance, the field of vehicular safety affords many opportunities for electronic development in the years to come.

The "electronic highways" could include a system computer with a memory device to keep track of every vehicle on the road and to maintain fixed intervals between the vehicles. Thus, any car seeking entrance to the highway could be programmed into the traffic flow in a vacant slot and at the speed established for all vehicles in the system. This technique would avoid traffic maneuvers, such as passing, and would eliminate merging, tail-end, or head-on collisions.

More sophisticated safety equipment might be contained within the individual automobile traveling the electronically automated highways. This could include a forward or rear-looking proximity warning device operating on the principle of radar or infra-red radiation. Such a device would automatically apply brakes to the car in the event that it is too close to another vehicle or that its rate of closure is excessive for a certain minimum distance of separation between vehicles. The same mechanism could be used on conventional roadways to warn a driver of an impending collision so that he could manually slow down.

Another electronic unit to enhance vehicular safety might appropriately be called the "Safety Signal Receiver." This would be a simple radio receiving set installed in each vehicle. Its exclusive purpose would be to receive official messages trans-

mitted to promote safety. These messages or signals would be controlled by law enforcement agencies and radiated to the vehicular receivers at discrete positions as needed along the roads. This technique would probably be most useful to manually guided vehicles traveling on roads as we know them today.

A typical transmitted message might be, "Five inches of water covering pavement 1.2 miles ahead. Decrease speed to 5 mph before reaching that point." Or, a fire truck or police car might carry a small, controlled radiation transmitter. While on an emergency mission, this transmitter would radiate a warning signal over a 4–5 block area to alert drivers that an emergency vehicle was speeding along in their vicinity. In the event of war, warning of an impending enemy attack could be transmitted to vehicles equipped with this receiver.

Another safety device might appropriately be termed the "Stop-Thief Alarm." A simple radio transmitter could be installed at some totally inaccessible location in the vehicle. If the car were started and put into motion without properly unlocking the doors and turning on the ignition key, it would transmit a distinctive r-f alarm signal indicating that the vehicle had been stolen. This signal would be received by law enforcement officials so that the criminal could be apprehended immediately.

Communications

The future should bring an ever-increasing demand to communicate between the automobile and home or office. Furthermore, futuristic electronic highways should result in automated vehicles with interiors to serve as a mobile office during intercity travel. This interior conceivably contains such things as a desk, a typewriter, a water cooler, and a dictation machine. There is just one essential missing from this automotive office scene. It's the telephone on the desk. AC Spark Plug is currently engaged in the development and production of vehicular two-way radio-telephone equipment.

Fig. 1 shows the AChieverfone — a new compact automotive phone. A major factor contributing to its small size is the development of a miniaturized selective signalling decoder. This device permits the telephone company operator to dial the discrete number assigned to a particular vehicle and have only that vehicle's telephone ring.

Fig. 2 shows a past-present-future evolution of decoders for vehicular telephone service. Note that through transistorization and new mechanical techniques, the present decoder has a capability for twenty-five times as many telephone number codes as its 1947 counterpart. Furthermore, it is about one-quarter the size of its predecessor. It is not unreasonable then that the decoder we expect to see before 1970 should have 10,000,000 codes and occupy a space no greater than 4.5 cu in.

Microminiaturized components can be used with r-f power transistors, tunnel diodes, and thin films throughout the entire vehicular telephone equipment to produce a unit which can easily fit into the glove compartment of your car by 1970. And, we expect the automotive telephone to grow from the present 18,000 vehicles equipped to approximately 5,000,000 within 10 years.

To Order Paper No. 390A . . .
from which material for this article was drawn, see p. 6.

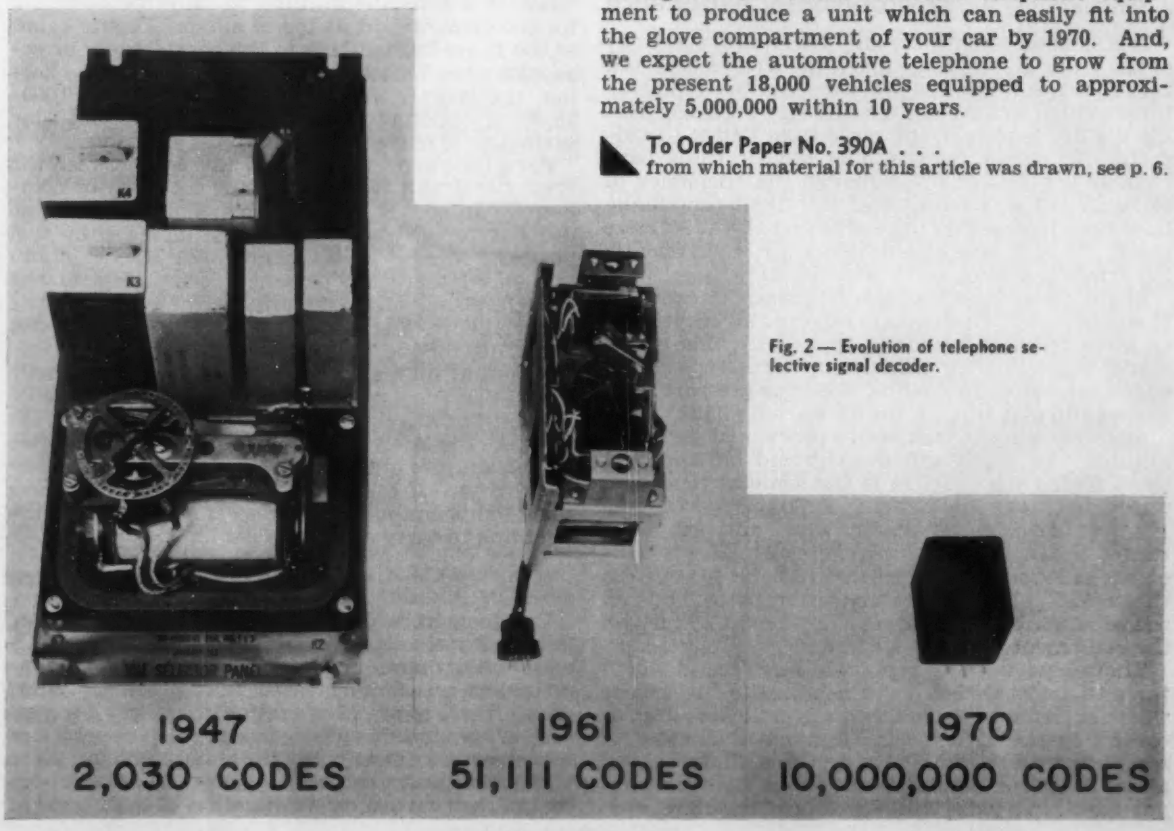


Fig. 2 — Evolution of telephone selective signal decoder.

PAA looks back at the 707

Based on paper by

R. W. Blake
Pan American World Airways, Inc.

A STOREHOUSE of experience has been gained by Pan American in the nearly three years it has been operating various models of the 707. Since July 1958, when they were first received, through March 1961, 133,997 aircraft hours had been accumulated — and enough distance covered for 2800 earth orbits. All this while much data have been collected, pointing out where improvements can be made and where the design has proved to be more than adequate.

Environmental experience

It is summer somewhere on PAA's routes every day of the year. By the same token the slush season is a continuing nine months problem. Surface temperatures as high as 113 F are encountered regularly during the hot season on the route from Beirut to Calcutta. In colder regions, fuel temperatures have gone as low as – 42 F. Although the frequency of exposure is low, geographical and flight time limits have been imposed on the use of fuel of – 40 F freeze point. This, to give a healthy margin when operating across oceans or arctic wastelands.

Flight crews report a high frequency of exposure to engine icing. One captain reported an occurrence on every trip last summer. Apparently, this is primarily crystaline ice particles in cirrus-type clouds which can cause fluctuation of engine pressure ratio gauges and may turn on the ice warning light.

Airframe icing has not been a problem at jet cruise altitude. In climb and descent and on low level short flights the problem is the same as it was on piston aircraft. The heaviest buildup reported was 1 in., which came off readily when anti-icing was turned on. Accuracy of thickness estimates is difficult to know since the wings are difficult to see from the cockpit. Usually the first evidence of ice is on the windshield, which serves as a warning to turn on the equipment.

There have been no reports of any case in which the anti-icing system could not handle the ice; or where external ice had caused any noticable drag or control system difficulties. A number of cases of stabilizer trim freezing have occurred, however, and a case of aileron binding, which could have been ice, has been reported. While modifications have been made to minimize moisture accumulation in critical areas, it is not yet established whether the problem has been fully corrected. Basically, the anti-icing equipment is judged adequate and necessary. The Q-feel-spring heater, though, is felt to be a "go" item.

With jet stream operation has come the expected very high wind velocities and clear air turbulence effects. The main difference from piston experience is the better capacity of using the jet stream when it was favorable and a greater need to avoid it when it was not, due to flying at altitudes closer to the core. Typical flight recorder readings in turbulence run ± 0.8g with a few extremes at ± 1.0g.

Trans-ocean flights are generally flown between 31,000–41,000 ft, step climbing in 2000–4000 ft increments. Flights of 1500–2500 miles in length are now flown at a constant altitude, usually the optimum for the gross weight at top of climb. Flights below 30,000 ft are limited only to the shortest legs or occasions when no other flight level is available. Earlier, the shorter flights were flown around 20,000–25,000 ft, shooting for minimum schedule, but time savings were marginal and fuel cost excessive.

For a time max cruise thrust was used between the West Coast and Honolulu in the interests of competitive speed. Here again the small gain in time did not prove worth the heavy increase in fuel burned. Normal cruise is now 0.82 Mach. Above this speed there are passenger complaints of the noise level, and also some evidence of a rougher ride in turbulence. The mean 1960 speed for the 707-300 was 0.816; for the 707-121 it was 0.79.

Non-stop flights such as the 4480 nautical mile Tokyo-San Francisco run, and the 4800 nautical mile London-Los Angeles flight, tax even the 707-300. It will take the 320 B to do the job properly, even after the capabilities of the 300 are improved by work now in progress. It takes favorable conditions to make these flights non-stop, and there is no question of attempting to carry a volume load limit.

Runway experience

Due to concern over runway length and strength, initial services started with weight restrictions almost everywhere. Time and the pouring of concrete has measurably eased that problem. After nearly three years of operation there has been no case of an airport where commercial jet operations has created a runway deterioration problem. Even where marginal strength was known to exist, jet operation has caused no acceleration of maintenance

Nearly three years of operation have shown that jet aircraft promise to achieve standards of mechanical and operational reliability better than anything approached by piston aircraft. Here are some of the experiences of the men who fly them.

requirements beyond the continued effects of previous piston aircraft use.

Fuel reserve usage experience

Studies made of fuel reserve usage since 1958 show a mean reserve usage ranging between 7% reserve consumption and 3% under consumption. Standard deviations for various routes ranged from a high of ±29.5% and a low of ±17.2%. To give an idea of what these figures mean in terms of load, typical ocean reserves run around 20,000–25,000 lb.

The reserves used in international operation under the U. S. Civil Air Regulations are judged to be conservative. The key indicator for evaluating a reserve system is the frequency of diversions. In the PAA studies, frequency of diversion ranged between 0–4%.

Noise

One of the first questions which arises when jet service is inaugurated to a new city is: what will the noise exposure be? To this day, take-off weights on one runway at Idlewild and runways at two other airports in the world are limited to avoid exceeding a certain noise level over the immediately adjacent community. Preferential runways and departure and arrival procedures have been established at scores of other airports. At two airports, limits on night operation have been set and are enforced.

At New York the problem was first eased by runwayway construction in directions which took the airplane away from the community. Advanced thrust ratings on the JT3 engine helped. Introduction of the 707-300 brought two improvements: better performance at the weights needed to fly the same routes and changed frequency spectrum of the engine noise. Subsequent increases in JT4 take-off ratings have helped further.

A standard flight technique used to combat noise is to maintain V_2 speed plus 10 knots and reduce thrust just before reaching any noise-critical area. Standard engine pressure ratios of 2.1 for the JT3 and 1.9 for the JT4 are used as a noise abatement thrust setting. Reduction is on a stop watch time, or over a visual landmark, at most places. At two airports a ground observer with a radio helps locate the correct spot more precisely for the crew.

Initially landing noise was considered to be the lesser problem. Today it is the cause of the most frequent public complaints. There is no leeway with this problem, though. The runway is where it is and so is the ILS. Attempts have been made to steepen glide slopes and/or move ILS reference points at some airports, with small practical effect. The most effective measures have involved traffic and limitations on minimum altitude while maneuvering around the airport.

Powerplant experience

The engine has been one of the brightest spots in the jet picture. Engine shut-down figures show that the average jet pilot would not expect to experience engine-inoperative flight, except in training, more than once in three years. This is even more impressive considering that the greatest single cause for in-flight shut-downs is a false fire warning. Not that the engines never malfunction; a good deal of this success can be laid to detection of troubles on the ground.

Several parts replacement programs have been made to correct hot section temperature problems on the JT3 and JT4. On the JT3 engine, even though the overhaul period has been allowed to double between early 1959 and late 1960, the hot section inspection between overhauls is still required. This type of problem is held basic in any wet engine due to the higher percent of dry rated thrust needed in cruise because of the additional weight that the wet take-off rating allows. The water system itself has a variety of problems, and the mineral content of water has been verified as being a critical factor.

Foreign object damage, contrary to original expectations, has not been a major problem. In the vast majority of cases when objects have gone through the engine, the damage still permits continued operation for the full overhaul period. To date, bird damage has caused only one case of premature overhaul and no case of in-flight shut-down.

After some early experiences with multiple engine flame-outs they have become practically nonexistent. The original flame-outs were due to water, which had accumulated in the anti-icing ducts due to leakage through seals in the water injection system, drowning the flame.

Instrumentation

A major program is in progress for improvement in auto-pilot coupler performance and reliability. The goal is nothing less than all-weather capability. In addition, PAA is developing a more attention-get-

PAA looks back at the 707

. . . continued

ting instrument failure warning system.

Although there have been the usual bugs in the new basic air data system, the basically new features have worked very well. The drum altimeter, for example, has been particularly well received by the pilots. Basic accuracy has proved within the ¼% quoted and reliability is good. One definite area for instrumentation improvement lies in the development of a Mach meter which can be more easily read in the cruise Mach range.

Chronic problems with the EPR gages and the flowmeters have been experienced. Vibration was the trouble with the EPR gage on the 121, largely overcome on the 300 by relocation of the transmitter. Accuracy and readability have been the problems with the fuel flowmeters. The same has been true of the fuel tank gages. They still cannot be relied on as the basic means for loading fuel on the airplane.

Improvement and growth

The following improvements have been incorporated in the PAA 707 fleet:

1. Increased JT3 thrust ratings. Parts for the advanced JT3C-6 take-off rating have been incorporated in all engines.

2. Increased JT4 thrust rating. The –10 rating, which have been completed, increased the take-off thrust from 15,800 lb to 16,800 lb. The –12 rating, which have just started, gave a further increase to 17,500 lb plus a 16% increase in cruise thrust. Both have improved the load-carrying capability off short runways on hot days as well as the ability to fly longer distances at 0.82 mach with a given load.

3. Tail modification of the 121 and 300 series. Engine-inoperative characteristics of the 707 are vastly better with the new tail; particularly the 121, which previously had no rudder boost. First the 121's were converted to the original 300 series tail; now both fleets are being converted to the final fully boosted rudder configuration with the fin extension and added ventral fin.

4. Fuel capacity increase of 707-300. Addition of three center section fuel cells provides 2450 gal more fuel capacity.

5. Structural weight increase of the 707-300. This is a 10,000 lb increase, which together with the increases in fuel capacity and engine thrust will further improve economics of the airplane on the longer flight stages. Two aircraft have been modified to date.

To Order Paper No. S309 . . .
from which material for this article was drawn, see p. 6.

Underwater

Based on presentation by

D. S. Hacker and P. Lieberman

Armour Research Foundation of Illinois Institute of Technology

FUTURE underwater vehicles may be propelled by underwater ramjet systems similar to the aerodynamic ramjet. Such a system is being studied in the hope of developing faster underwater vehicles than conventional propeller systems.

The main advantage of using a ramjet rather than an underwater rocket is a slightly higher specific impulse for the ramjet. When compared at the same velocity for the same distance, the ramjet is a more efficient device. The ramjet propulsion system is basically for short range operation; long range missions being precluded by the high rate of power consumption. Unfortunately, these propulsion systems are still very noisy.

A typical configuration for the vehicle might be that shown in Fig. 1. The ramjet must be initially boosted so that water is introduced to the combustion chamber at sufficient ram pressure to sustain operation. If a ramjet is launched at a velocity above that which will permit sustained operation, the vehicle will accelerate until the onset of cavitation, where thrust and velocity become steady. The fuel in the combustion chamber is water reactive, so that the water sprayed into the chamber acts as a co-propellant. The reaction products are expanded through a critical Laval nozzle.

Only a fraction of the total energy released by the propellant is utilized by the working fluid. About 50% of the available heat is used to raise the sensible heat of the water to saturation condition, adding little to the thrust efficiency. The remainder is used to vaporize the water in order to do useful work.

The speed of the underwater ramjet is determined by the existence of a positive net thrust condition at velocities below the cruising velocity. Cruise velocity is quite sensitive to the ramjet design parameters since they affect net thrust. For example, the inlet cross-sectional area must be designed so as to optimize the mass flow rate of water into the combustion chamber. A typical ramjet would operate at about half of the design thrust if the water intake were doubled. It would operate at only slightly above the design thrust if the water intake were reduced by half.

Too much water intake tends to quench the reaction. Consequently, the quantity of steam formed

ramjets may drive subs faster

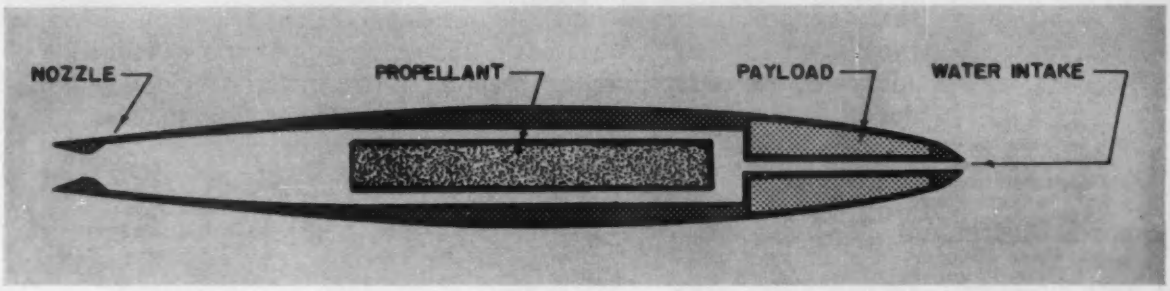


Fig. 1 — **Possible design** for an underwater vehicle having ramjet propulsion.

in the combustion chamber is insufficient to permit an ideal expansion process, resulting in low thrust. On the other hand, too little water intake will result in a superheated state of steam of such high specific volume that the design ram pressure may be insufficient to permit passage of the intake mass flow rate. In this case water would have to be diverted from the intake until a stable condition of correct intake water flow is reached. Thrust would be improved slightly, but the operation in the superheat region increases heat transfer losses and calls for special materials which maintain integrity at high temperatures. It is expected that if the state in the combustion chamber lies in the reasonable temperature zone of the two-phase region, then thrust will vary only slightly with flow rate. Reduced flow will improve thrust, but at a diminishing rate, as the superheat region is attained.

In addition to the intake passage design characteristics, the water intake rate also depends on the vehicle's forward velocity. At the extreme boundary conditions of maximum and minimum allowable water intake, typical operations would require only small intake area variations. Therefore, the operational limits of the ramjet are narrow because they are easily reached by small variations in intake area.

The exhaust nozzle expansion process introduces further operational limitations. If it is assumed that the water droplets and steam vapor form a homogeneous mixture with equal velocities at each transverse section of the nozzle, the critical expansion process will depend on the ratio of combustion chamber pressure to the nozzle back pressure. High stagnation pressures and low back pressures are desirable for full expansion of the exhaust jet. Therefore, the best operating condition is achieved at a high forward velocity and shallow depths.

There is a supersaturation limit of expansion beyond which the fluid will not behave as an ideal fluid. Then the expansion of a steam mixture through a supersonic nozzle will depend on the initial drop size of the moisture in the wet steam. If large drops are present (10^{-5} in. diameter), a discrete increase in pressure will be observed and a transition to the mist state occurs. During the expansion process the specific heat of the condensed liquid droplets is greater than that of the vapor. The mixture will not attain equilibrium and the drops will be hotter than the vapor. Anything that will disturb this metastable condition will condense the entire fluid and cause separation of the fluid from the nozzle walls and a loss in thrust.

Thermodynamic analysis has shown that the underwater ramjet may never develop satisfactory thrust to overcome drag effects, especially with the propellants available today and when the possible energy losses are considered. Improved propellant configuration and composition, and other heat sources would aid in performance. In addition, the expansion of a three-phase mixture, such as exists in the ramjet, must be investigated to learn more about behavior and contribution to nozzle losses.

Management:

Teach your engineers to design better with adhesives

The rapid advances in adhesive technology are resulting in materials that have been proved; their use now depends, in part, upon providing the design engineer with a basic understanding of the capabilities of adhesives. Adhesive Bonding Training Programs pay dividends in reduced costs, fewer production worries, and improved quality.

Based on report to SAE Engineering Materials Activity Committee by

James E. Austin and Lloyd C. Jackson
The Bendix Corp.

AUTOMOTIVE, electronic, packaging, marine, industrial, aircraft, missile, and other industries which must keep pace with modern designs should seriously consider instituting an Adhesive Bonding Training Program for their engineers, as a means to effect cost reductions, reduce production difficulties, and improve quality.

The intent of the course would be to provide the design engineer with a general background of information on essentially all of the basic types of adhesives, so that he may be able to design his part better while recognizing the complexities of adhesive selection and application. This would result in better communications from drawing board to production assembly, supplementing the roles of the materials engineer or the technical salesman.

The following is a typical four-hour basic adhesives course, presented in two sessions.

Adhesive Characteristics

Advantages and disadvantages

Advantages of adhesive bonding

1. Allows fabrication of smoother contours.
2. Permits use of lighter weight (gage) materials.
3. Serves as vibration dampener.
4. Joins dissimilar materials.
5. Provides greater stress distribution.
6. Permits weight savings.
7. Reduces costs.

Disadvantages of adhesive bonding

1. Poor resistance to sunlight, heat, cold, rain, and such.
2. Solvent in adhesive deteriorates the surface of the adherends.
3. Selection of material having too short a pot life.
4. Certain equipment being required for use with specific adhesives.
5. Wrong choice of adhesive formulation.

Classifications

There are several ways to classify adhesives. Table 1 classifies by vehicle. Other methods of classifying adhesives are: by chemical composition (thermosetting, thermoplastic, elastomeric, natural); flowability (flow, nonflow); bonding type (heat, time, pressure, catalyst, vulcanizing, reactivation); form (liquid, paste, powder), and others.

Adhesion factors

The strength value of an adhesive that a supplier describes in his literature is based on his observance of certain conditions. Be careful in selecting the appropriate surface preparation procedure, to allow maximum wettability and avoid starved glue lines or contamination by fingerprints. Do not move bonded joints before the adhesive has been sufficiently cured. Internal stresses can be created, if the coefficient of expansion of the adherends and the adhesive differ greatly during elevated temperature cure cycles. The chart shown in Fig. 1, which is qualitative only, indicates that less than desired strengths can result when the adhesive does not completely wet the adherend, or the cured adhesive has undesirable stresses developed into it.

Design concepts

In an ideal tensile loaded joint, the forces are perpendicular to the plane of the joint and the stress is distributed uniformly over the entire bonded area (Fig. 2). The entire joint is under equal stress at the same moment and all of the adhesive contributes to the strength of the joint.

In an ideal shear-loaded joint (Fig. 2), the forces are parallel to the plane of the joint and again

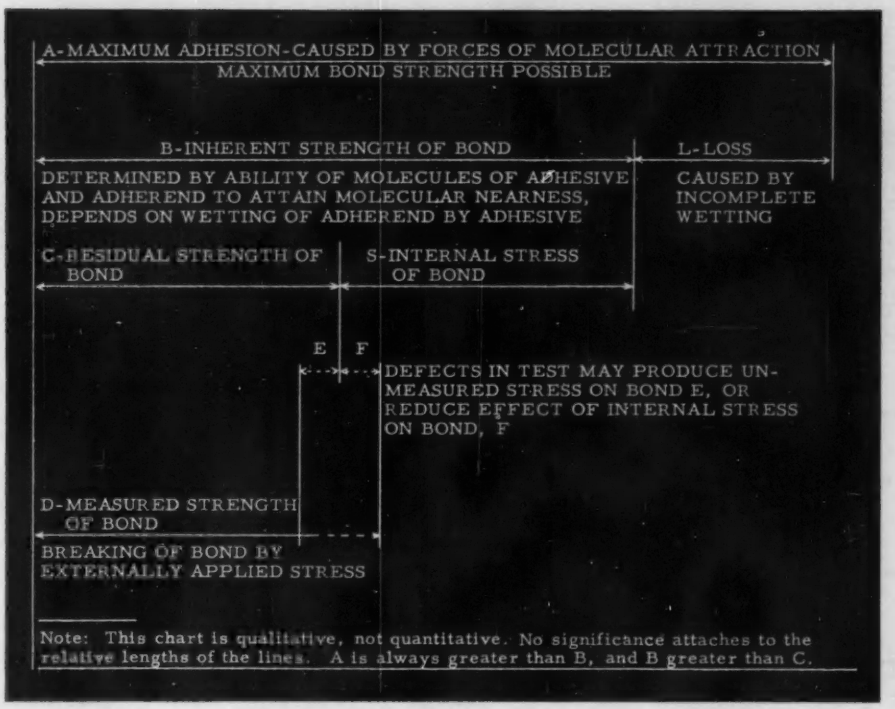

A-MAXIMUM ADHESION-CAUSED BY FORCES OF MOLECULAR ATTRACTION
MAXIMUM BOND STRENGTH POSSIBLE
B-INHERENT STRENGTH OF BOND
DETERMINED BY ABILITY OF MOLECULES OF ADHESIVE AND ADHEREND TO ATTAIN MOLECULAR NEARNESS, DEPENDS ON WETTING OF ADHEREND BY ADHESIVE
L-LOSS
CAUSED BY INCOMPLETE WETTING
C-RESIDUAL STRENGTH OF BOND
S-INTERNAL STRESS OF BOND
E
F
DEFECTS IN TEST MAY PRODUCE UNMEASURED STRESS ON BOND E, OR REDUCE EFFECT OF INTERNAL STRESS ON BOND, F
D-MEASURED STRENGTH OF BOND
BREAKING OF BOND BY EXTERNALLY APPLIED STRESS
Note: This chart is qualitative, not quantitative. No significance attaches to the relative lengths of the lines. A is always greater than B, and B greater than C.

Fig. 1 — Relations between factors involved in adhesion. Poor strength can result when the adhesive does not completely wet the adherend or the cured adhesive has undesirable stresses developed into it.

Table 1 — Classification of Adhesives by Vehicle

Type	Solvent Dispersion	Water Emulsion	100% Reactive (100% solids)
Form	Liquids, pastes, tapes, supported films	Liquids	Pastes, films
Adhesive Alloy	Elastomer (rubber or vinyl butyral) + thermosetting resin (phenolic, sometimes epoxy or alkyd)	Reclaimed rubber + asphalt; milk latex	Usually modified epoxies (others for films)
Bonding Requirements	Usually pressure and/or heat, solvents (reactivation type)	Heat and/or pressure	Contact pressure; choice of room temperature or heat cure
Advantages	Flowability; easy to apply in film or tape form and from dispensing bottles. Can be reactivated after drying. Allows widest choice to formulator.	Most inexpensive of the three. Eliminates fire hazard. Consistency can be varied by adding water.	No time wait for solvent release. Eliminates fire hazard. No attack on vulnerable adherends. High heat resistance. Fills void.
Limitations	Care must be taken to allow for solvent release if both surfaces are nonporous (not usually recommended). Solvent may interact unfavorably with certain plastics.	Usually limited to bonding where at least one surface is nonporous. Some types require high pressure. Freezing damages bonding properties.	Peel, stretch, and impact properties not usually as high as in others. Not freely flowing. Usually supplied as two-component adhesive requiring mixing. High shear strength falls rapidly above specified temperature.
Remarks	Elastomer adds flexibility, peel, and impact strength.	Curing characteristics highly influenced by added modifiers.	Highly suited for metal-to-metal bonds, electrical uses.

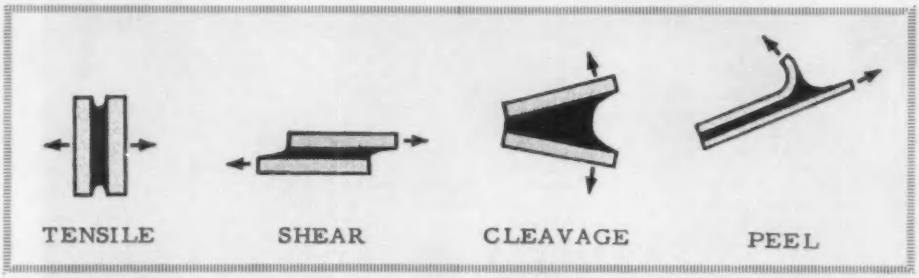


Fig. 2—Adhesives can be subjected to a variety of stresses.

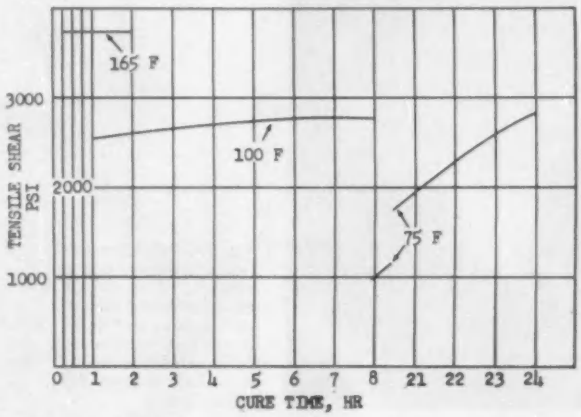


Fig. 3 — Characteristics of a particular epoxy adhesive under different cure time and temperature relationships.

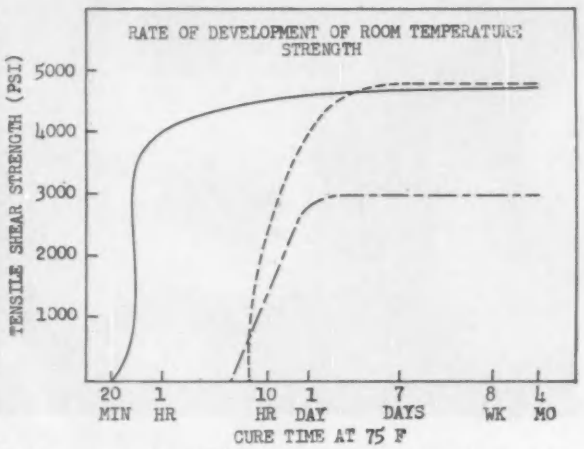


Fig. 4 — Characteristics of three epoxy adhesives subjected to room temperature cure conditions.

Management:
Teach your engineers to design better with adhesives

. . . continued

stress is distributed uniformly over the entire bonded area. All of the adhesive is at work at the same time to provide maximum joint strength. This type of joint is more frequently used than the tensile-loaded joint, because it is more easily fabricated.

When a joint is stressed in cleavage (Fig. 2), the forces are not distributed uniformly over the entire bonded area, but rather all of the stress is concentrated on only a small portion of the adhesive. As force is applied, one edge is under no load at all. The cleavage loaded joint is much weaker than a joint of the same area under tensile or shear loading, and should be avoided in joint design.

In a bond subjected to peel stress (Fig. 2), the stress is confined to only a very thin line at the edge of the bond. Here, only a fraction of the total bonded area is being used and even less adhesive is contributing to the strength of the joint than in the cleavage loaded joint. Even more than cleavage, this type of stress should be avoided in adhesive joint design. Therefore, it is advisable to design joints for tensile and shear loading conditions and minimize cleavage or peel stress from the design configuration.

Cure time and temperature

The temperature and time of cure is important in the selection of adhesives, because of shipping schedules, available ovens for elevated-temperature-curing adhesives, down-time caused by fixtures being tied up, and so forth.

The characteristics of a particular epoxy adhesive under different cure time and temperature relationships are shown in Fig. 3. First, note from the chart that when the adhesive is applied and allowed to cure at room temperature, there does not appear to be any strength developed for at least eight hours. Although the adhesive is curing, sufficient strength has not developed until the eight-hour period has passed, the adhesive then continues to develop its strength for the next 16 hours.

A main disadvantage here has been the long wait, and possibly the tying up of a fixture necessary to hold the parts in the proper position. Now note that just by the addition of 25 deg of heat during the cure process, we need wait only one hour before the joint reaches the bond strength it took the room temperature cure to reach in 24 hours. Increasing the cure temperature to 165 F, a complete cure occurs in just 15 min, with added strength.

The important points to note from the chart are: (1) The temperature at which the adhesive is cured will be a determining factor in the final bond strength of the joint; (2) As the temperature is increased, the curing reaction is speeded up, thereby allowing increased production potential; (3) The adhesive requires a set-up period prior to development of any bond strength at all. Although this chart will not apply to all adhesives, it serves to demonstrate what this type of adhesive is subject

Table 2 — Properties of Some Types of Structural Adhesives

TYPE →	Modified Epoxies: Room Temp Cured	Modified Epoxies: Heat Cured	Phenolic Elastomeric	Phenolic Thermoplastic
Curing Procedure				
Temperature, F	70–90	320–500	300–400	250–350
Pressure, psi.	contact	contact	25–200	50–200
Time, min.	1-7 days	2–60	2–60	30–120
Mechanical Properties				
Shear Strength, psi				
– 65 F	350–2500	1300–5000	3500–4500	2000–3000
68 F	2500–4200	3000–5000	2000–6000	2500–5000
180 F	180–900	2600–5000	1500–2800	800-4000
250 F	–	800–3600	500–2500	100–1800
300 F	–	450–3200	400–2220	100–1200
350 F	–	200–1900	300–1700	100–500
Creep Strength				
Room Temp.	excellent	excellent	good	excellent
Elev Temp.	poor	good	good	good
Peel Strength	poor	poor	excellent	fair-good
Flexibility	poor	poor	excellent	fair-good
Chemical Resistance				
Water	fair	excellent	good	excellent
100% Humidity	fair	excellent	good	excellent
Salt Spray	poor	excellent	good	excellent
Oils	excellent	excellent	good	excellent
Glycols	good	good	good	excellent
Fuels	excellent	excellent	good	excellent

to, relative to temperature and time of cure. Other types of adhesives will have their special cure parameters.

Look at the characteristics of three epoxy adhesives under similar cure conditions, in Fig. 4. Note that one develops a rather high value of bond strength in a short period of time, when cured at room temperature. The second one requires a much longer cure time and develops a similarly high value of bond strength. The third adhesive has bond strength of a little over half the other two, yet cures in about the same amount of time. It can be seen here that an adhesive is available for your specific application.

Properties of various types of adhesives, cured at both room temperature and at elevated temperature, are shown in Table 2. You must clearly define your design requirements, if the proper choice of adhesive is to be made.

Work life and bondability time

The work life of an adhesive in a pot or container must be differentiated from its bondability life after application to the surfaces of the assembly to be bonded. For example, a rubber based solvent adhesive may be used directly from its container for several hours, but upon application to the surfaces to be bonded the adhesive may only be sticky for up to 30 min.

Two-part epoxy adhesives may have work lives ranging from 15 min to more than nine hours (Fig. 5), but may require a considerable number of hours before bond strength has been developed. Resinous adhesives may be usable from the pot for hours, but upon application to wood or paper may have open assembly time of minutes. Each type of adhesive will have its own characteristics, and there may be variations within types. These must be considered.

Application

Surface preparation

Surface cleanliness is primary in importance in an adhesive bonding operation. Much time and study is put into adhesive formulations. However, the best adhesive formulation in the world will perform below standard, if attention is not given to the preparation of the surfaces to be bonded. The manner in which metal surfaces are prepared for optimum bonding strength is quite different than for plastic surfaces.

Metal surfaces can be prepared for subsequent adhesive bonding in several ways, such as: chemical cleaning (acid or alkaline etching); abrading (sandpapering, sandblasting); solvent cleaning (vapor degreasing or other solvents); coating (anodize, metal plating). The bond strength may vary, according to the procedures selected.

Plastic surface preparations require differing techniques; some can be cleaned by solvents, some will react to the action of acids or bases, others can have their surfaces prepared for subsequent adhesive bonding as shown in Fig. 6.

Wood, in addition to mechanical abrasion to provide a smooth contact surface, also requires that temperature and humidity be controlled.

Rubber products may or may not require abrading, depending upon the type of rubber (solid or foam).

Causes of bond failure

Typical causes of bond failure have been compiled

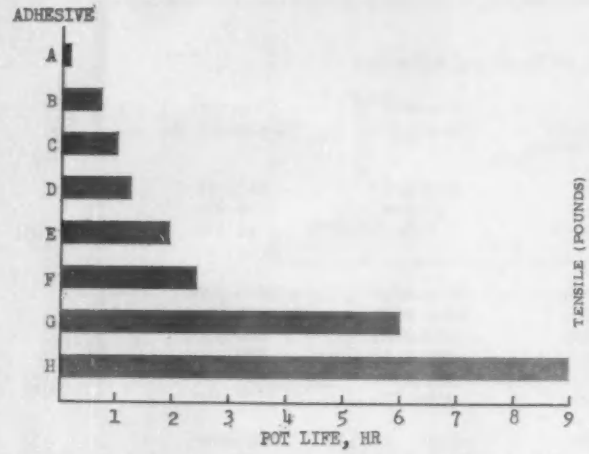


Fig. 5 — Pot-life of various two-part epoxy adhesives. These adhesives may have work lives ranging from 15 min to more than 9 hours, but may require considerable time for bond strength to develop.

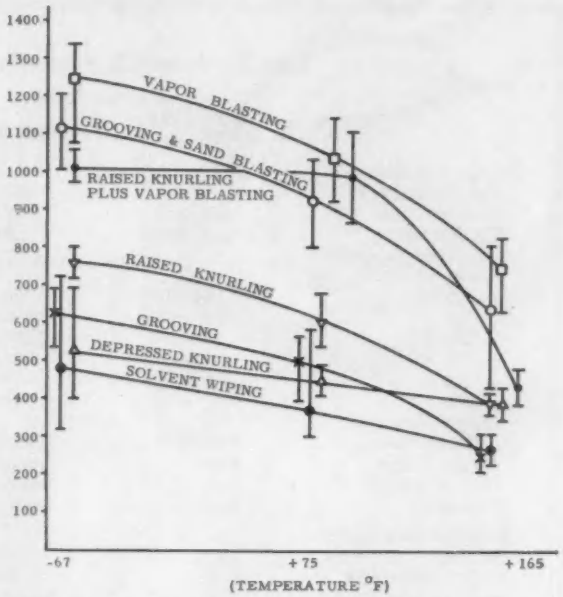


Fig. 6 — Effect of plastic surface preparations on bond strength.

Table 3 — Common Causes of Bond Failure

Type of Failure	Solution
Thermosetting Adhesives	
Cohesive failure	Check film with solvent used in adhesive. If solvent softens the adhesive film or becomes tacky, this indicates insufficient cure. Make sure bond line time and temperature is used.
Adhesive failure from metal	If metal surface has a white, clean appearance, check cleaning technique.
Adhesive failure from substrate other than metal	Try prime coat of diluted adhesive, also check compatibility.
Cellular areas in adhesive line	Increase pressure and/or adhesive.
Contact Adhesives	
Room temperature setting — tacky film	If film should dry hard but remains tacky, the cause may be entrapped solvent or migration of plasticizer from one substrate.
Shiny areas	Poor contact, insufficient pressure or insufficient amount of cement.
No bond	If heat reactivated type, adhesive was too cool at time of assembly or poor compatibility.
Failure in adhesive from metal	Improper cleaning.
From substrate other than metal	Incompatible or unclean surfaces.
Hot Melt	
No bond	Incompatibility, adhesive too cool at time of assembly. Parts too cool at time of application of adhesive.
Epoxy Base Adhesives and Casting Compounds	
High exotherm	Mix lower volume and pour mixed material into shallow tray. Cool base and activator before mixing or use metermixing equipment.
Tacky film or casting	Improper base activator ratio, improper mixing of base and activator, improper cure. Check bond line temperature.
Flexible casting or film of rigid adhesive or casting compound	Improper mixing of base and activator, improper base and activator, improper cure. Check bond line temperature.

Fig. 7 — Lap joint (left) is a favorite adhesive bonded joint (specimen in shear). Increasing the bond results in distortion of the metal and creates cleavage (center). A still greater load results in the metal developing a bend at the point of adhesive contact which, in turn, creates a condition of peel.

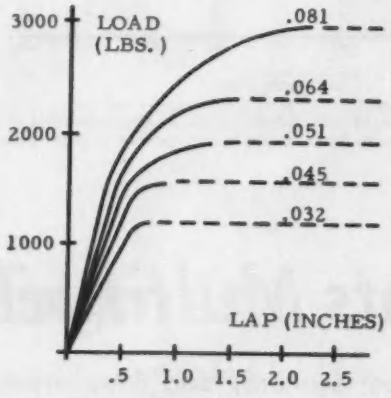


Fig. 8 — Metal thickness affects the strength capabilities of lap joint.

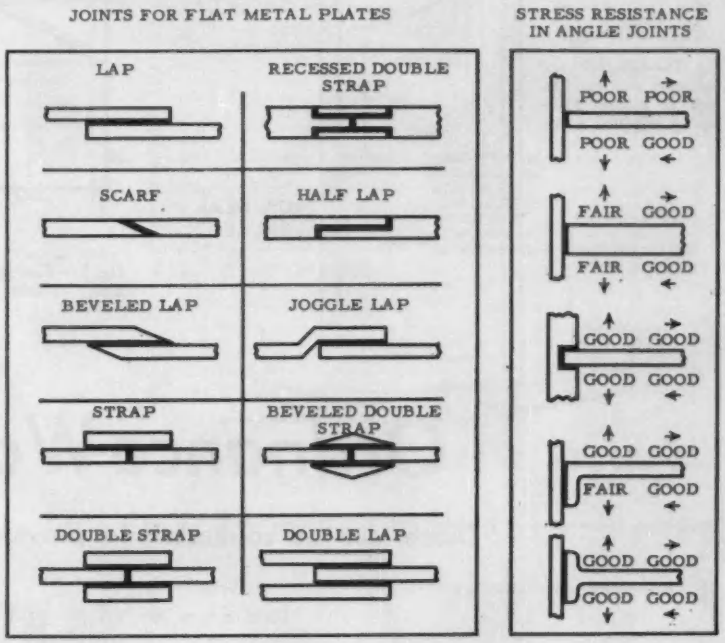


Fig. 9 — Design tips for adhesive bonding.

Management:
Teach your engineers to design better with adhesives

. . . continued

in Table 3. General classes of adhesives are listed, with common causes of their failure and a possible solution to the problem. This information should be especially valuable in helping you correct a situation that otherwise would suggest eliminating the adhesive from your design.

Design tips

One of the favorite adhesive bonded joints used appears to be the lap joint (specimen in shear) (Fig. 7 — left). However, the thickness of the metal will further affect the strength capabilities as shown in Fig. 8. This may be explained by considering the extent of the load that is placed on the bonded specimen. In the lap joint the potential forces are not parallel to the direction of the planes of the specimen.

Increasing the bond results in distortion of the metal and creates cleavage (Fig. 7 — center).

A still greater load results in the metal developing a definite bend at the point of adhesive contact which, in turn, creates a condition of peel (Fig. 7 — right).

The softer the metal, or thinner the metal, the sooner the above conditions will develop.

All of these considerations must be judged, as parts are to be bonded with adhesives. This is comparable to other types of fastening operations, where details such as drill speed, rivet size, rivet material, and such must be considered.

The selection of a joint design can result in nominal machining costs, or be very expensive, depending upon your requirements. Proper selection of joint design is, therefore, important in providing adequate or optimum bond strength (in the directions of stress encountered in the product's end use). Several design suggestions are presented in Fig. 9.

Cleanliness

Fingerprints can cause bond failures. Other contaminants which can cause bonding failures include: hair oils, greasy rags, dust, lubricating oil, silicones, and such innocent things as lens cleaning tissues, hand lotions, and even airborne vapors.

Some of the things we have listed as contaminants may seem a little unusual . . . for instance, hair oil. But think how many times you unconsciously scratch your head and then carry the hair oil to the part on your hands. Hand lotion and waterless soap are difficult to detect in evaluating a bond failure.

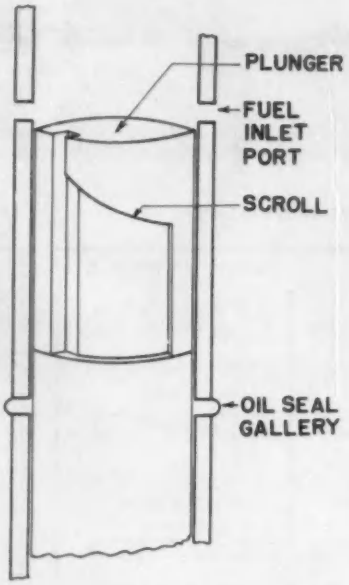


Fig. 1 — Oil seal used on Deutz multifuel engine to prevent leakage of injection pump.

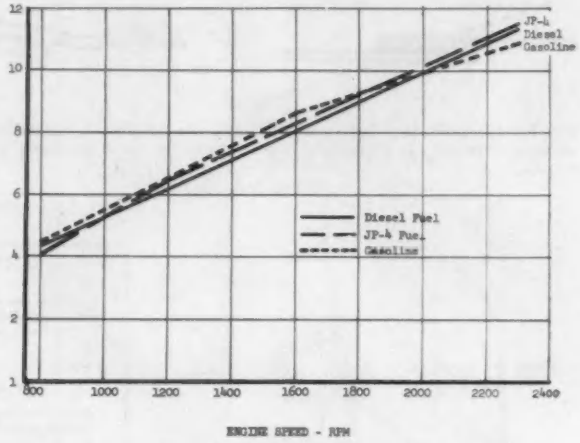


Fig. 2 — Fuel flow (gal/hr) versus engine speed of Deutz multifuel engine. Greatest change in metering occurs with gasoline at high speed.

Ordnance Wants Multifuel

Diesel can be converted to provide fuel economy and omnivorous

Based on paper by

James C. Emanuel

Aberdeen Proving Ground

Material drawn from paper presented at

SAE Joint Army-Navy Industry Meeting held by SAE Baltimore Section

THE MULTIFUEL engine sought by the Ordnance Corps must have fuel economy and the ability to run on all fuels in order to keep logistic problems within bounds. It must start and operate over a temperature range of −25 to 115 F, without off-engine auxiliary equipment, using all fuel from medium octane through middle distillates. And it must have a low lb/hp ratio.

The gasoline engine offers no promise for satisfactory conversion. It requires high-octane, highly volatile fuels, produced from a very narrow range of the available fuel spectrum. Its economy is disappointing, even with fuel injection, and economy is of primary importance to logistics.

The gas turbine is a multifuel engine and in time should approach the diesel in fuel economy at part and full load. Meanwhile, the diesel engine offers the best prospects for early adaptation to multifuel operation.

Problems face diesel conversion

There are two problems involved in making a multifuel engine out of a monofuel diesel. These are ones of maintaining control of combustion and maintaining fuel efficiency. Modifications to solve these problems introduce others which must be overcome to get a satisfactory engine. Monofuel engine combustion is controlled by controlling the variables — ignition delay, rate of pressure rise, and mixture distribution to get the best performance from a particular fuel.

Multifuel engine design is more complex. Engine conditions providing good combustion control with one fuel may be entirely wrong for another. Ignition delay and rate of pressure rise vary considerably from one fuel to another as is shown in Table 1. The similarity in combustion characteristics displayed by diesel fuel and JP-4 explains why a diesel can operate on JP-4 without difficulty. Had this study been made with a conventional (unconverted) diesel, assuming the engine could be made to run on gasoline, it would show a much wider variation between fuels.

Engines cannot be modified to compensate for changes in fuel characteristics, according to Ordnance specifications. The variables controlled by juggling with a monofuel engine must be let alone with the multifuel engine. The basic fact in multifuel engine design is satisfactory performance on all fuels with injection timing, nozzle opening pressure, and all other variables remaining constant. Maximum performance on each fuel must be sacrificed to multifuel capability.

Controlling combustion with multifuel engines

To get combustion control in the Deutz multifuel engine, design was concentrated on reducing the long ignition delay on gasoline. External lag was reduced by shortening high pressure lines and re-

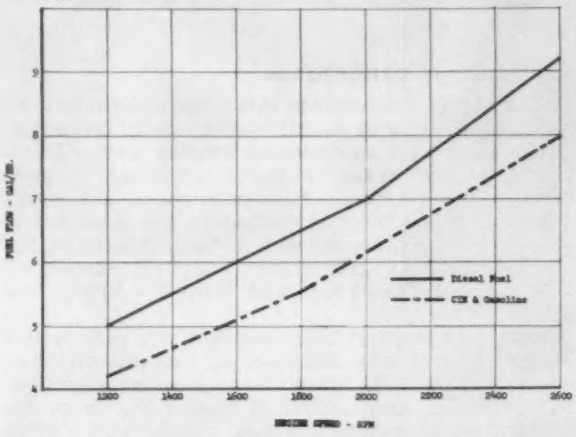


Fig. 3 — Fuel flow versus engine speed of Continental 427 engine. Shift to lighter fuels brings loss of about 15% in injected volume.

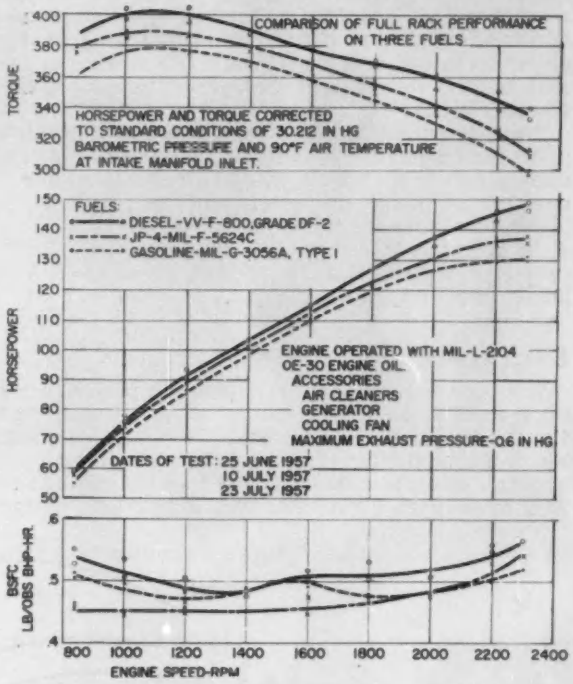


Fig. 4 — Deutz power curves show similarity of performance regardless of fuel used.

Engines

capacity demanded by logistics.

ducing nozzle opening pressure. Physical and chemical delay was reduced by increasing compression temperatures through:

1. Raising compression ratio from 17.8/1 to 21/1.

2. Increasing average precombustion chamber temperature by casting the chamber into the head without a metallic bond, thus inhibiting heat transfer.

3. Holding cylinder head and intake air temperature high, particularly at idle and light load, by thermostatic control of the cooling fan and intake air heater.

These measures reduce ignition delay on all fuels, but especially on gasoline.

Continental Motors employs the MAN controlled evaporation principle for its 427 multifuel engine. The fuel is puddled on the walls of the combustion chamber rather than sprayed into the air. A carefully controlled air swirl evaporates the fuel from the chamber surface in layers so that each layer burns in orderly succession. The combustion rate is slowed and there is a correspondingly low rate pressure rise on any fuel. In addition, intake ports are designed to produce air swirl without restricting air intake as masked valves would do, and the compression ratio has been raised.

Both Deutz and Continental designs are capable of controlling combustion on all fuels.

Getting fuel system efficiency

Most standard pumps are designed to use the fuel to seal as well as lubricate the plungers. When gasoline is the fuel, large amounts seep past the plungers to dilute lube oil. Parts wear, fuel metering is affected, and large amounts of vapor are produced in the fuel gallery.

Deutz, with its Robert Bosch pump, gets around this difficulty by building a small gallery near the bottom of the cylinder barrels of the injector pump (Fig. 1). Oil is kept in this gallery at engine oil gallery pressure to serve the two-fold purpose of lubrication and plunger sealing. Vapor formation is reduced by doubling fuel gallery pressure, reducing the vapor forming spaces produced by action of retracting valves, and circulating three or four times the amount of fuel required by the engine through the pump to wash back vapors to the fuel supply.

The full rack fuel flow of the Bosch pump on three fuels is shown in Fig. 2. The only significant change in metering is seen to occur with gasoline at the top of the speed range.

The American Bosch pump used on the 427 engine

Table 1

Ignition delay and rate of pressure rise in Deutz multifuel engine at idle, operating on three fuels.

	Ignition Delay, deg	Rate of Pressure Rise, psi per deg
Diesel Fuel	16.4	29
JP-4	18	38
Gasoline	23.5	97

has a single plunger which oscillates as well as rotates and is serviced with lube oil under pressure. It was adapted to multifuel operation by increasing gallery pressure, redesigning high pressure passages and delivery valves, and increasing the size of the transfer pump.

Fig. 3 shows fuel metering for this pump at constant rack setting. The loss on injected volume on shift to lighter fuels is about 15% and fairly constant over the engine speed range. The loss in efficiency is greater than with the Deutz pump, but this is not to say that it is inferior. This pump works with nozzle pressures in excess of 2500 psi whereas the Deutz nozzles open at 1200 psi.

Effectiveness of modifications

The best test of multifuel capacity is performance on several fuels. Fig. 4 shows the performance of the Deutz engine on diesel fuel, JP-4, and gasoline. Fig. 5 shows similar curves for the Continental 427 engine. Here, maximum power loss on gasoline is 23% diesel power, but even on gasoline this engine outperforms the gasoline engine it was designed to replace.

Cold-starting performance

The higher compression ratios are a slight help to the cold-starting of multifuel engines, nevertheless, both Deutz and Continental employ aids. Deutz uses glow plugs in the combustion chambers in series with electric resistance heaters in the intake manifolds. This engine has started in less than 3 min at – 65 F. Continental uses a flame heater in the intake manifold. Its engine has been started at – 40 F in less than 1 min and down to – 50 F in the field.

Fuel consumption is no problem. In fact, better economy is usually obtained on gasoline than on diesel fuel or JP-4. Weight reduction is no particular problem. One multifuel engine has been developed which weighs less than 6 lb/hp and 4 lb/hp appears possible for larger size engines.

To Order Paper No. S303 . . .
from which material for this article was drawn, see p. 6.

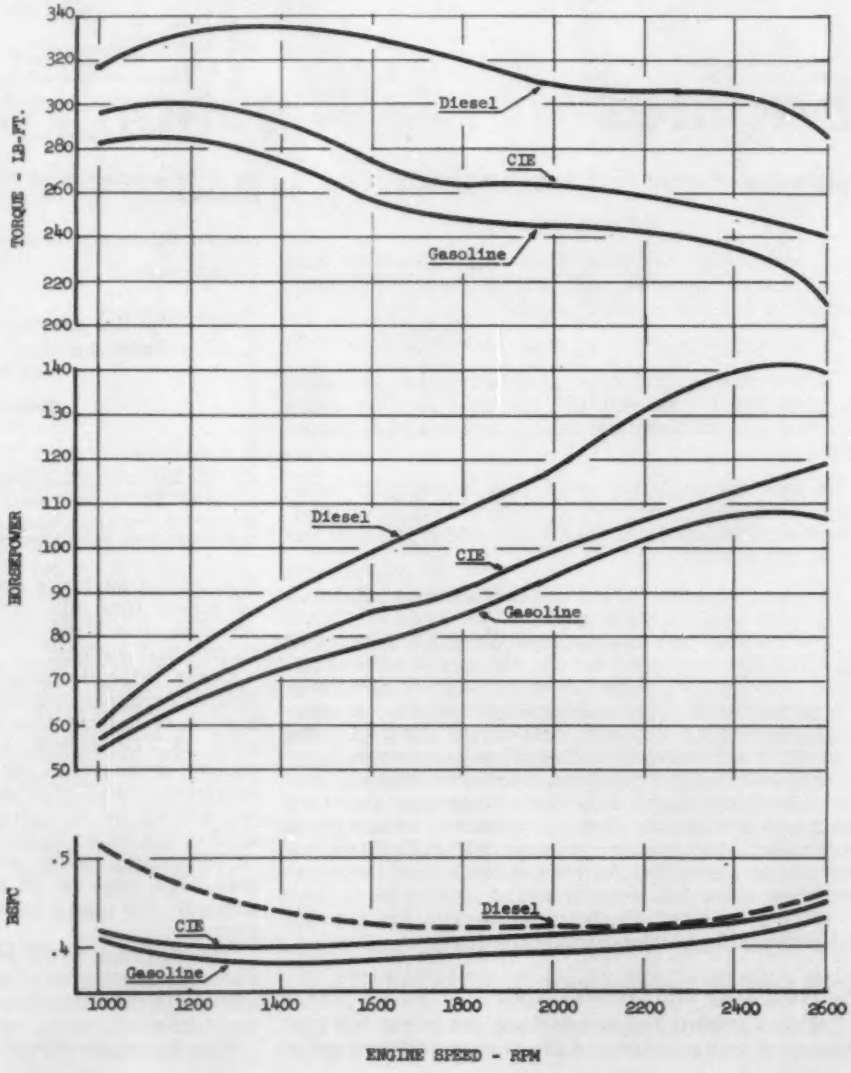


Fig. 5 — Full rack performance of Continental multifuel engine using three different fuels.

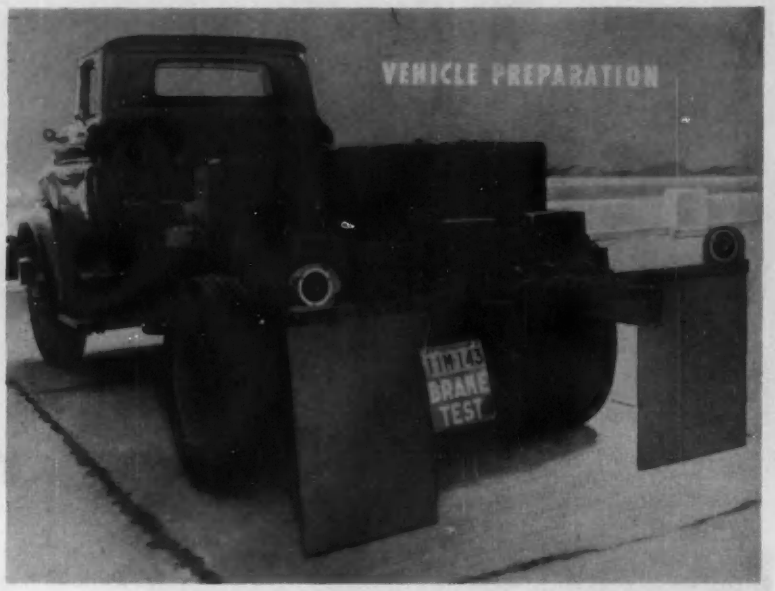


Fig. 1 — **Truck loaded for testing.**

New brake rating test guides brake choice

Tests show different brakes have equivalent ratings.

Based on paper by

D. Paul Fisher

Chevrolet Motor Division, GMC

A BRAKE RATING TEST procedure and a formula relating brake rating to vehicle gross weight has been developed by a joint brake committee of the AMA-TTMA (Automobile Manufacturers Association-Truck Trailer Manufacturers Association). The test objective is to determine the number of brake snubs which can be made in a specified period of time, while maintaining specified deceleration and stopping distance requirements. With a maximum number of snubs established, the horsepower rating can be established.

The original aim in developing the brake rating system was for vehicle certification purposes. It is felt, however, that a bona fide brake rating will replace some of the "guess and try" practices currently used in selecting brake equipment in the vehicle design stage.

Brake tests to date indicate that brakes having varying combinations of diameters, widths, and lining materials may have equivalent ratings. The engineer, then, has a choice of brake specifications — helping him to keep within space limitations.

Vehicle test preparations

Prior to rating of single unit trucks the vehicle must:

- Be loaded to rated GVW with the weight distributed so each axle is loaded as closely as possible to its rated capacity, with as low a center of gravity as possible to avoid undue weight transfer, Fig. 1.
- Be equipped with the largest production engine available for the chassis being tested.
- Have new or relatively new tires.
- Have sufficient brake balance to obtain 15 ft/

Fig. 2 — **Thermocouple installation** for measuring brake temperature.

New brake rating test guides brake choice

. . . continued

sec² deceleration without locking any of the brake groups.

- Have adequate pressure available in the brake system to provide 90 psi service air pressure, or 1800 psi hydraulic pressure, with not more than 200 lb pedal force.

The new linings required for this evaluation must be burnished as follows:

- Make 200 brake applications at 40–20 mph and 10 ft/sec² deceleration, except for every tenth snub — these are made from 50–15 mph at 15 ft/sec² (only a single deceleration rate is used for combination vehicles). All snubs are made at one mile intervals with the transmission in neutral or clutch disengaged. The speed between brake applications is 40 mph.
- Immediately following the 200th application, 10 applications are made at two minute intervals, from 50–15 mph at 15 ft/sec². Brake temperatures are recorded on all these snubs.

Instrumentation

The following instruments are used to provide the required data:

- "U" tube decelerometer.
- Fifth wheel speed indicator or calibrated speedometer or tachometer.
- Detonator or equivalent to measure stopping distance.
- Line pressure gauge.
- 50 ft tape.
- Stop watch.
- Selector switch and 0–1000 F direct reading pyrometer for measuring brake temperatures. The most highly energized shoe of each brake group must be equipped with a temperature measuring unit.

Fig. 2 shows the thermocouple installation. On air brake units it is installed on the leading shoe and on the foward brake shoe for hydraulic brakes. The thermocouples are made with ends of wires twisted 3/16 in. back, and silver soldered.

Rating test procedure

All brakes on the vehicle are tested as a unit in this procedure. Three cycle tests must be run to establish a rating — the two initial tests being run at reduced energy levels. The procedure for each cycle is as follows:

- **Cold stop.** Make an emergency cold stop from 20 mph at maximum deceleration obtainable (remaining within the previously stated pressure limits). Record stopping distance and line pressure.

- **Warm up.** Make a series of brake snubs from 40–20 mph at 10 ft/sec² at ½ mi intervals. Check brake temperature after each snub. Record temperature and maximum line pressure on first and final snubs.

- **Rating test.** This is a 12 min test, to be run immediately after the warm up, in the following manner: Bring the vehicle to 15 mph. Start the stop watch and accelerate the vehicle to 50 mph as quickly as possible. Now a predetermined number of snubs is made according to the chart in Fig. 3. The number of snubs, it is seen, depends both on gross vehicle weight and on the particular cycle of testing being conducted. The number of snubs required is read to the nearest integer and the proper time for each snub cycle is found to the right of the curves. Each cycle starts at 15 mph as the vehicle accelerates to 50 mph. The brakes are applied only during the last 5 sec of each cycle, bringing the vehicle back to 15 mph. The deceleration should be kept at 12 ft/sec². On the final rating cycle a deceleration rate of not less than 9 ft/sec² must be maintained. After the final rating test is completed and the brakes are cooled to 200 F for the hottest brake, the brakes must give no evidence of pull, grab, or premature lock-up during subse-

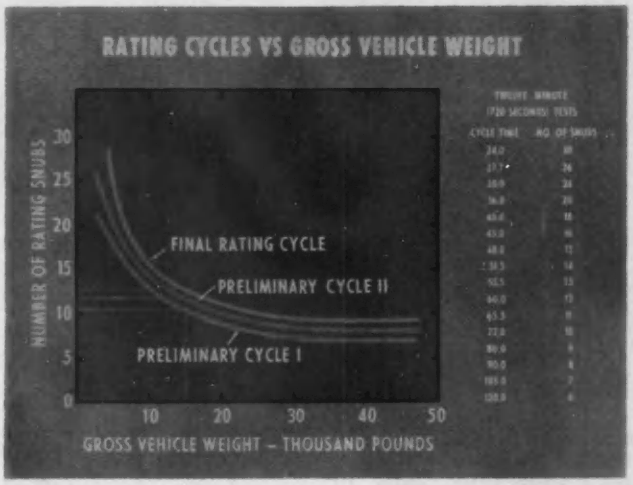

RATING CYCLES VS GROSS VEHICLE WEIGHT
NUMBER OF RATING SNUBS
FINAL RATING CYCLE
PRELIMINARY CYCLE II
PRELIMINARY CYCLE I
GROSS VEHICLE WEIGHT - THOUSAND POUNDS

Fig. 3 — **Number of snubs** versus gross vehicle weight for 12 minute tests.

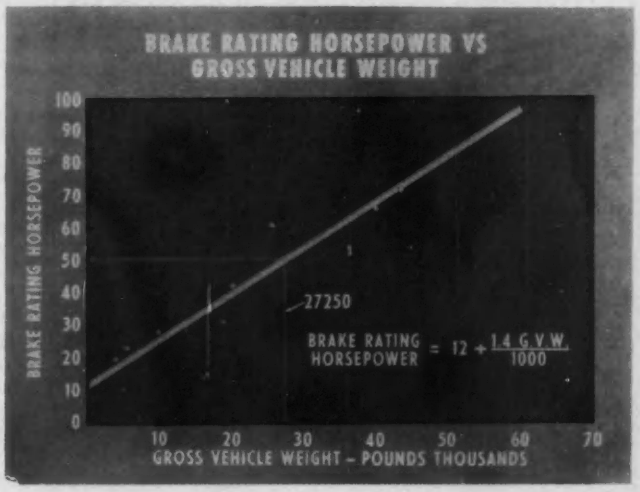

BRAKE RATING HORSEPOWER VS GROSS VEHICLE WEIGHT
BRAKE RATING HORSEPOWER
27250
BRAKE RATING HORSEPOWER = 12 + 1.4 G V W / 1000
GROSS VEHICLE WEIGHT - POUNDS THOUSANDS

Fig. 4 — **Relationship** between minimum brake rating and gross vehicle weight.

quent operations. Do not exceed 90 psi service line air pressure or 1500 psi hydraulic pressure on any snub. Record maximum line pressure used, maximum and minimum deceleration, and all brake temperatures after each snub.

Immediately following the final snub on the rating cycle, make an emergency stop from 20 mph. Do not exceed 90 psi for air brakes or 1800 psi for hydraulic brakes. Record stopping distance and line pressure used. Stopping distances for this test and the cold stop test are given in Table 1, and must not be exceeded.

For tractor-trailer combinations, the brake systems of each unit must be evaluated separately. When possible, the tractor should be loaded to its rated GVW and tested as above. If it cannot be loaded to its rated GVW a trailer must be used to make the total weight of the combination as close as practicable to the tractor GVW or trailer axle ratings, whichever is being tested. The weight distribution must be such that the axles to be rated are loaded to approximately 0.7 of their ratings to prevent wheel slippage.

Table 1 — Stopping Distances

Vehicle Classification	Brakes Cold	Brakes Hot
Under 10,000 lb GVW	25 ft	30 ft
2-axle with GVW 10,000 lb and over	35 ft	42 ft
3-axle with GVW 10,000 lb and over	40 ft	48 ft

Correction factors

The total Gross Combination Weight will generally exceed that desired for rating the brakes on the axle being tested. In such cases it is necessary to apply corrections to initial velocity, deceleration rate, and stopping distances. The corrections are made

New brake rating test guides brake choice

... continued

in accordance with the following formulae:

Speed correction formula: $V_3 = \sqrt{2275 \frac{W_1}{W_2} + \frac{W_1}{225}}$

Deceleration correction formula: $F_2 = \frac{W_1}{W_2} \times \frac{W_1}{V_3} \times F_1$

Where:

W_1 = test axle rated load.
W_2 = total weight retarded by brakes on test axle.
V_1 = standard test speed (50 mph) from which retardation starts on vehicles operated at rated GVW.
V_2 = standard test speed at which the brakes are released.
V_3 = corrected test speed from which retardation starts on vehicles operating at other than rated GVW.
F_1 = standard deceleration rate for either burnish or rating tests.
F_2 = corrected deceleration rate.

Horsepower rating

The horsepower rating is determined by the following formula:

$$\frac{W\ (V_1^2 - V_2^2)\ N}{2 \times 32.2 \times 550 \times 720} \left[1 - \frac{T_1}{T_2} \right]$$

Where:

W = GVW of the vehicle in lb.
W_1 = initial speed in ft/sec.
W_2 = final speed in ft/sec.
N = number of snubs made in 720 sec.
T_1 = actual amount of time the brakes are applied (sec) when decelerating from 50 to 15 mph.
T_2 = average drift time (sec) when decelerating from 50 to 15 mph. It found by letting the vehicle coast from 50–15 mph, with transmission in neutral, in the direction(s) in which the rating test will be conducted.

For the standard 50–15 mph cycle, this formula simplifies to:

$$\text{BRHP} = 1.91 \times 10^{-4}\ WN \left[1 - \frac{T_1}{T_2} \right]$$

Test results

A large number of tests were run on a wide range of vehicles, brake types, sizes, and linings. The results of these tests are summarized in Fig. 4, along with a suggested relationship between a minimum brake requirement and GVW. The actual test results are plotted as points. In practical applications the curve can be used to obtain a truck GVW rating. For example, a brake rating horsepower of 50 would permit a gross vehicle weight rating of 27,250 lb.

To Order Paper No. 364B ...
from which material for this article was drawn, see p. 6.

Subs may

Based on paper by

John H. Harrison
U. S. Naval Engineering Experiment Station

FISH may show the Navy how to solve the propulsion-machinery-system noise problem in underwater craft. By studying the various aspects of sea-animal locomotion it is hoped that ways to radically improve noise characteristics will emerge. New approaches such as this probably hold the only hope of meeting the Navy's needs, as marginal improvements are all that can be expected in the intrinsically limited existing systems.

Sea-animal locomotion is one of the few areas where the animal kingdom continues to challenge the attainments of modern technology. The sea environment exacts a steep price for inefficiency of form and movement. Nevertheless, fish and cetacean animals such as whales, dolphins, and porpoises, have met the problem, all with some degree of success.

Sea animals possess many enviable characteristics which could be used in naval propulsion machinery systems. These include: quietness, high propulsive speed, high endurance, and high efficiency. One other desirable feature is the integration of the propulsion device, maneuvering device, and the hull, with no protrusions through the basic hull.

The surprising thing about SAL is the seemingly "impossible" speed at which some sea animals move. Consider the case of a 6-ft porpoise swimming at 20 knots. The weight of muscle in such an animal is about 35 lb. According to measurements of the power available from the muscles of other mammals, such as men and dogs, the tissue is only capable of about 0.01 hp per lb of muscle at a sustained rate. Applying tests data to the porpoise means that it would only be able to develop about 0.35 hp. Now, the coefficient of drag for rigid streamlined bodies has been measured, and for the 6-ft porpoise swimming at 20 knots the skin friction drag coefficient $C_d = 0.0028$. Adding a small amount of "form" drag brings the total drag coefficient up to 0.003. Using this coefficient to calculate the drag power gives 3.14 hp. The actual muscle power required would be about 3.7 hp if it is assumed that the porpoise converts muscle power to drag power with 85% efficiency — the propulsion efficiency of a ship's propeller.

Apparently, the porpoise has only about one-tenth of the power it needs to swim at 20 knots. The discrepancy becomes even greater at a speed of 25 knots, which has been observed, since propulsion power rises as the cube of the speed.

This paradox is not limited to the case of the

swim like fish

Material drawn from paper presented at

SAE Joint Army-Navy Industry Meeting held by SAE Baltimore Section

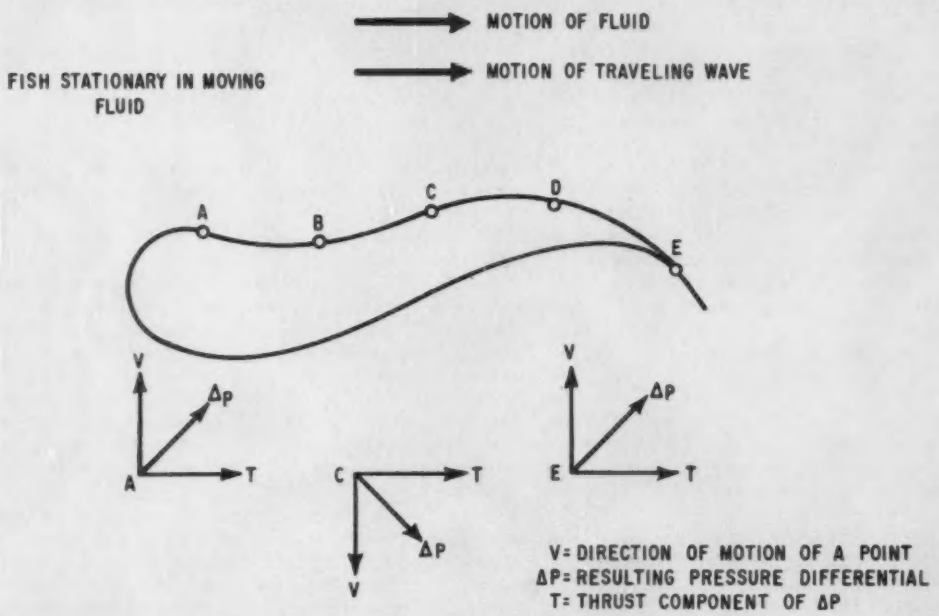


Fig. 1 — Motion and forces on the body of a fish.

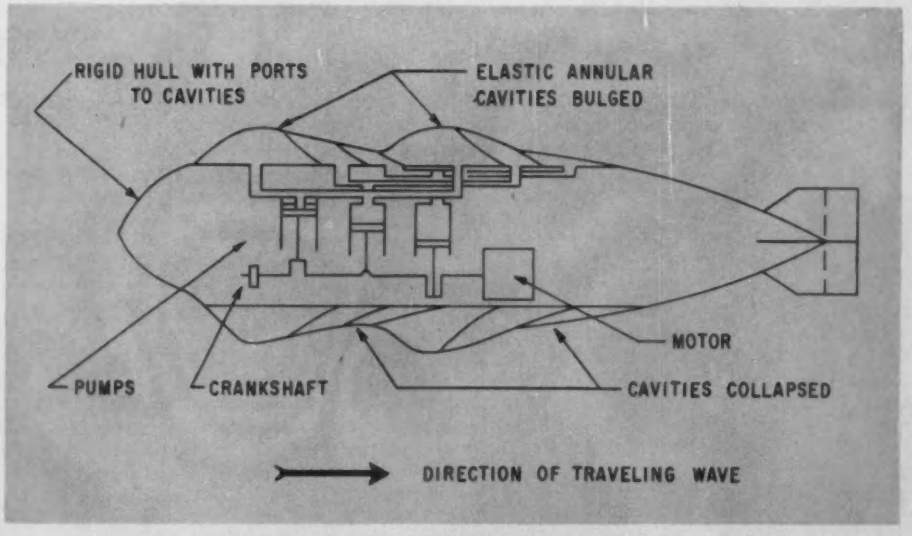


Fig. 2 — Hull-undulation propulsion system.

Subs may swim like fish

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porpoise. Consideration of the respiration and oxygen requirements of whales result in substantially the same conculsion. Physiologists have examined time and size scaling factors in whales and concluded that the heart and artery load would be intolerable. Studies of barracuda have concluded that the estimates of power loading for mammalian muscle must be increased by 10 or more. Also according to conventional hydrodynamic calculations, the average fuel load of fat for a salmon traveling back to its parent stream should be about six times that actually available.

Some investigators have offered the explanation that sea animals use some special technique to maintain laminar flow about them. If the porpoise can maintain laminar flow over its entire body, then the coefficient of drag at 20 knots might be as low 0.0003. The power requirement would then diminish by the ratio:

$$\frac{C_d \text{ (laminar)}}{C_d \text{ (turbulent)}} = \frac{0.0003}{0.0030} = \frac{1}{10}$$

accounting for the discrepancy. This conclusion is a little difficult to accept since many fast sea animals have a very rough surface, and in some cases most of the swimming is in water which is already turbulent.

The same manner which sea animals use to attain speed is thought to also account for their quiet and wakeless locomotion. It is not yet established that the fastest fishes swim silently at high speed, though submerged whales do, and these can travel at 21 knots. But from the contrast between noisy submarines and torpedoes and sea animals moving at similar speeds, it can be deduced that sea animals are at least comparatively quieter at the higher speeds.

With present underwater vehicles, noise generated by the flow of water around the hull is a problem in the higher speed ranges. Even before, in the ascending speed scale, the propeller-propulsion system creates noise problems. Noise reduces the capabilities of submarine or torpedo sonar systems at higher speeds. Porpoises, on the other hand are reportedly capable of locating openings in nets at distances of two miles or more with their sonar "eyes." Such a feat would probably not be possible if the porpoises' locomotion system were noisy.

It has also been found that SAL approaches an ideal "wakeless" propulsion system in which the hull wave is wiped out. Moving vehicles are followed by a turbulent wake consisting of two countermoving parts. One part is the hull wake, a region, aft of the vehicle containing fluid moving with the vehicle. It results from drag or friction against the hull. The other part is the propeller wake or race, a conical region inside the hull wake containing fluid and neutralizing the forward momentum of the hull wake. Studies conducted in bioluminescent water have shown that the wakes of bodies such as torpedoes are brilliantly visible, while the wake behind seals is barely visible, and that of a porpoise is almost undetectable.

Just how do sea animals attain these superior performance characteristics? Most recent investigators believe that it is their body undulations are significant in achieving fast and quiet locomotion. It is claimed that these body motions create a sort of "propeller race" in exactly the same location as the "hull wake" thereby wiping the wake away.

The undulating body motions used by many sea animals are used for high-speed travel and quick darts or acceleration to cruising speed. Acceleration is achieved by large body undulations with the head moving side-to-side and extensive tail fin involvement. Moderate speeds are maintained with most fins folded close to the body, which undulates in a carangiform manner (single traveling sine wave). At high speed, rapid ripples pass aft along the body with motion approaching anguilliform (multiple traveling sine wave). The amplitude and wave length are decreased, but frequency is greatly increased.

High-speed photographs of fish, porpoises and eels, show that most of these animals do employ an anguilliform motion when swimming at high speeds. Fig. 1 schematically represents the motion and forces on the fish's body. All parts of the body have lateral motion V which results in a pressure differential, ΔP, over ambient pressure. The useful component of ΔP is the thrust T. Most of the surfaces of the body except those like B, which have zero slope with respect to the axis of travel, participate in the propulsive process. This action could energize the boundary layer at all but a few nonstationary points. Thrust would be generated at, or close to, points where drag would occur and drag would be canceled as it tended to build up. The transition to turbulent flow would also be postponed indefinitely. This form of motion may also achieve a form of boundary layer control through effectively blowing and sucking and a rhythmic change in aspect.

Some fish have a pressure sensitive line along each side which, investigators believe, helps also in postponing transition. It has been proposed that transition might possibly be postponed by some mechanism which would obviate the pressure variations that have been found to precede transition. It has been argued that the fish may sense local pressure variations and actively respond in such a manner as to damp out the variations and stabilize the boundary layer.

A concept that has been offered which would simulate SAL to propel a ship is shown in Fig. 2. This system uses an undulating hull made of some resilient material and formed over a rigid hull. Ports would connect the rigid hull to cavities formed in the resilient material. In this diagram, the resilient material would be driven in and out by pneumatic or hydraulic pressure. The same effect could probably also be achieved with mechanical linkages. The expansion and contraction of the various portions of the elastic material would be so phased as to effectively represent a wave travelling down the hull. Such a propulsion system would probably be quiet, efficient, and almost wakeless.

To Order Paper No. S307 . . .
from which material for this article was drawn, see p. 6.

Miniaturized fluid control subsystems make moving mechanical parts passé

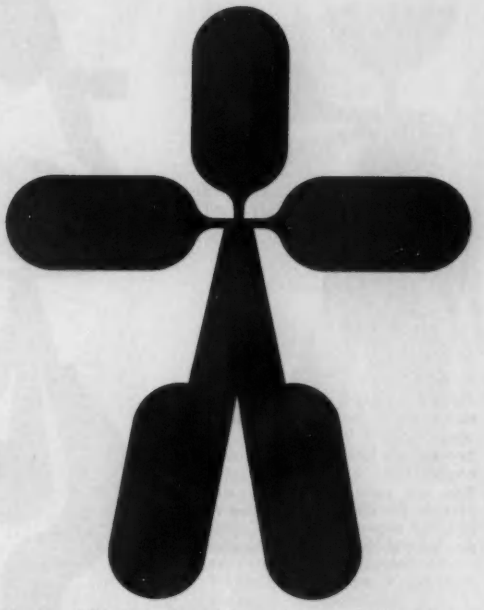

Fig. 1 — Silhouette of amplifier having two stable states — all flow to the right output or all flow to the left output. Control signal applied to right control chamber shifts flow to left output and vice versa.

Based on report presented before SAE Committee A6 Aero Space Hydraulic and Pneumatic Systems and Equipment by

Dr. R. E. Bowles

Diamond Ordnance Fuze Laboratories

MINIATURIZED fluid control subsystems are being built from digital and logic components having no moving mechanical parts. New design and production techniques will provide these components and systems for research and development programs in pure fluid systems.

System requirements

Fluid control subsystems must be able to provide:

AMPLIFICATION — control of a high power level main fluid flow by a lower power level control fluid flow.

FEEDBACK — utilization of a portion of the main fluid flow energy to provide a control fluid flow.

ENERGY STORAGE — accumulation of energy in the form of fluid kinetic or potential energy (inertance or capacitance).

PHASE SHIFT — control of the relative time of arrival of a fluid signal at different locations in a feedback path.

COMPARISON — ability to compare an input signal with a standard value.

Subsystem components

Amplification can be provided by a beam deflection fluid amplifier. The "beam" is a high energy fluid power stream. This stream is guided to the target area or receiving apertures which, in turn, are connected to the amplifier loads.

Two techniques are used to guide the power stream. The first is to blow against the side of the power stream with one or more control streams. From conservation of momentum relationships the tangent of the power stream deflection angle and information as to how the power stream enters the receiving apertures can be calculated. This technique is called Stream Interaction Control.

The second technique is to control the pressure distribution along the sides of the power stream. This is done by using the power stream to supply or entrain fluid from the adjacent regions or boundary layers, and by concurrently controlling influx or egress of a separate control fluid for these same adjacent regions. This way a pressure difference is set up transverse to the power stream. Controlling this pressure difference controls or guides the power stream. This technique has been termed Boundary Layer Control. When one or more of these amplification techniques is used in an element the element is considered an active component.

Passive components also are needed to store fluid inertia or fluid potential energy or to decrease the availability of the energy. In fluid systems there

Fig. 2 — Binary stage silhouette has single power nozzle input, single control signal input location, and two output locations. Each time a control signal is applied the output flow will switch from its current path to the alternate path and remain in that flow pattern until a new control signal has been applied.

are, for example, both linear and nonlinear inertance, capacitance, and resistance components. The passive components are relatively straight-forward; a volume is a capacitance, a long column has a higher inertance than a short column, a passageway having a large surface area per unit of cross sectional area has a high resistance to flow. These fluid passive components correspond to the electrical capacitor, inductance, and resistor with reservations.

One of the major differences between the electronic component and the fluid system component is that electronic components normally consist of different materials that are assembled into different structural configurations. Every pure fluid component consists of an absence of the structural material. Thus the entire system of amplifiers, resistors, capacitors, inertances, and connections between components can be made by a common process which removes the structural material in the desired pattern. A two-dimensional pattern is desirable from a production standpoint. Such patterns can be molded, stamped, and etched.

Component silhouettes

There are many types of fluid components both analog and digital. Let us consider the silhouettes of three typical digital components. The first (Fig. 1) is an amplifier having two stable states, all of the flow to the right output or all of the flow to the left output. This is a flip flop. If flow is to the right output and a control signal is applied to the right control chamber then the unit will start delivering flow to the left output instead of the right. Similarly if flow is to the left output and a control signal is applied to the left control chamber then the flow will switch to the right outlet. This particular design is very insensitive to the output load. For example, one outlet can be blocked completely yet the power jet will keep trying to follow its latest control signal and flow to the proper receiving aperture.

The second silhouette (Fig. 2) is based on a binary stage. It has a single power nozzle input, a single control signal input location, and two output locations. Each time a control signal is applied the output flow will switch from its current path to the alternate path and remain in that flow pattern until a new control signal has been applied (Fig. 3). This is a basic component for binary computation. When staged, the right side output location is used as a readout signal while the left or end output location is used as the input of a succeeding binary stage. Two input control signals must be applied to cycle one output from ON to OFF to ON.

The third silhouette is an OR EXCLUSIVE component (Fig. 4). Considering the silhouette as a baseball player, if a signal is applied to one or both hands flow will be deflected by the contour of the player's back and exit the front leg. If a signal is applied only to the player's head flow will lock onto the chest wall and exit the front leg. Flow to the front leg therefore indicates application of a control signal at one or both hands or the head. If a signal exists at both the head and one or both hands, flow will go to the rear leg. The head flow shields the hand flow from the back wall and simultaneously the hand flow detaches the head flow from the front wall. Thus flow to the rear leg indicates existence of a hand signal and a head signal while flow to the front leg indicates existence of a hand signal or a head signal but not both a hand and head signal. This type of unit is used to examine a digital system for a particular set of conditions or to command a digital system to perform a particular sequence of operations.

These three silhouettes are intended only to provide a general picture of the types of patterns which are included in a Pure Fluid System. All of these components and interconnections require only a common process which removes the structural material in an appropriate pattern.

Design of a subsystem

The steps required to design a fluid control subsystem are:

1. The computer or control system logic is established and laid out as a block diagram with a minimum crossing of data flow lines.
2. The block diagram symbols are replaced by silhouettes of the appropriate fluid components by attaching to a white backup board. These silhouettes are five times the final size.
3. The components are interconnected by strips of black tape.
4. Four index patterns are located on the drawing to identify a reference dimension (four corners of a square enclosing the pattern).
5. A photograph of the black and white, undimensioned drawing is taken so that the resulting negative is the size of the desired pattern using the index patterns as reference dimensions. Note: This negative is the exact silhouette of what will result from the complete process. Any error in this negative as to circuit, omission of a connection between components, or incorrect scale will also be in the final item.

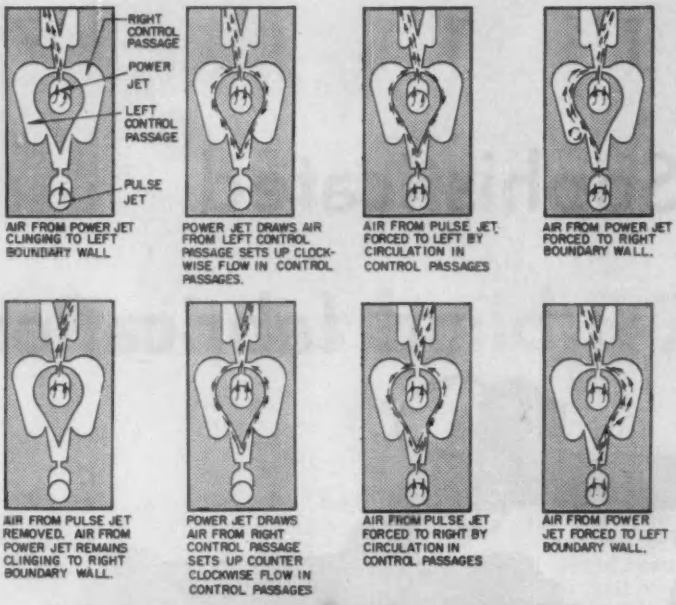
RIGHT CONTROL PASSAGE
POWER JET
LEFT CONTROL PASSAGE
PULSE JET
AIR FROM POWER JET CLINGING TO LEFT BOUNDARY WALL.
POWER JET DRAWS AIR FROM LEFT CONTROL PASSAGE SETS UP CLOCK-WISE FLOW IN CONTROL PASSAGES.
AIR FROM PULSE JET FORCED TO LEFT BY CIRCULATION IN CONTROL PASSAGES
AIR FROM POWER JET FORCED TO RIGHT BOUNDARY WALL.
AIR FROM PULSE JET REMOVED. AIR FROM POWER JET REMAINS CLINGING TO RIGHT BOUNDARY WALL.
POWER JET DRAWS AIR FROM RIGHT CONTROL PASSAGE SETS UP COUNTER CLOCKWISE FLOW IN CONTROL PASSAGES
AIR FROM PULSE JET FORCED TO RIGHT BY CIRCULATION IN CONTROL PASSAGES
AIR FROM POWER JET FORCED TO LEFT BOUNDARY WALL.

Fig. 3 — Complete cycle of binary stage fluid component shown in Fig. 2.

Fig. 4 — OR EXCLUSIVE component is used to examine a digital system for a particular set of conditions or to command a digital system to perform a particular sequence of operations.

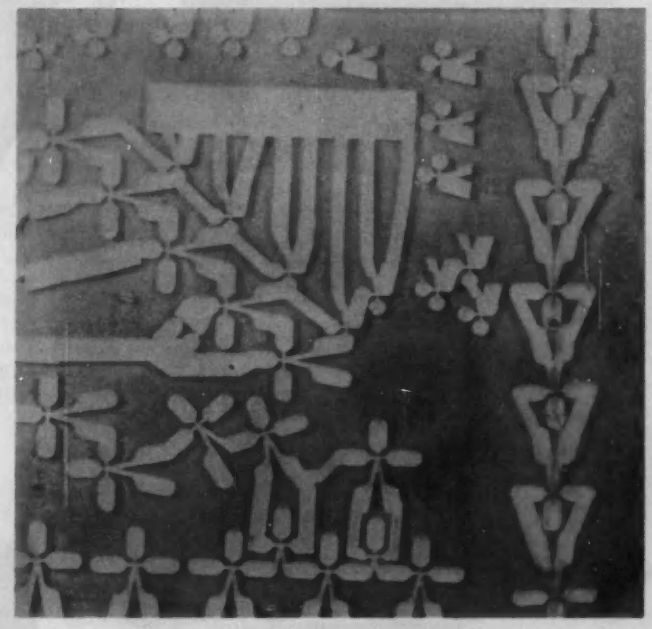

Fig. 5 — Part of a miniaturized fluid control subsystem. Components are etched in glass.

6. This negative is sent to a leading glass company.
7. The glass company makes contact duplicates of your negative on a special film as a production line master.
8. The production line master is used on an existing production line as a mask during exposure of FotoForm B glass to ultraviolet light so that a contact print is made on the glass.
9. The exposure is developed by a heat treatment and acid etched to the desired depth.
10. A second pattern can be processed on the same piece of glass etching to a different depth. This capability is needed for a unit wherein one pattern must completely penetrate the plate while the second pattern representing the basic circuit must only partially penetrate the plate. This enables one to introduce or extract power or control signal flow at any location in the system pattern.

Anticipated normal time between furnishing a negative to the glass company and receipt of a production line model is three to four weeks. Part of a typical model is shown in Fig. 5.

Sophisticated fabrication

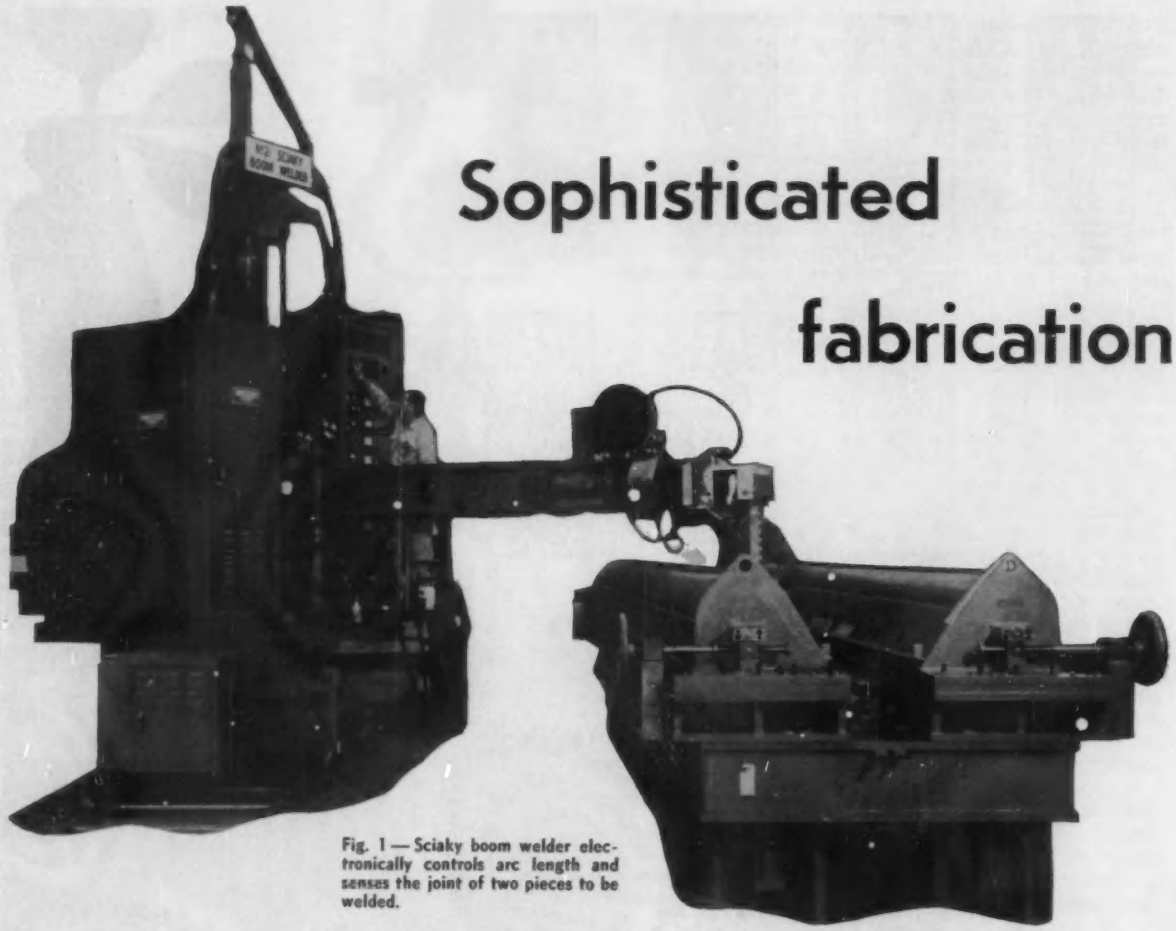

Fig. 1 — Sciaky boom welder electronically controls arc length and senses the joint of two pieces to be welded.

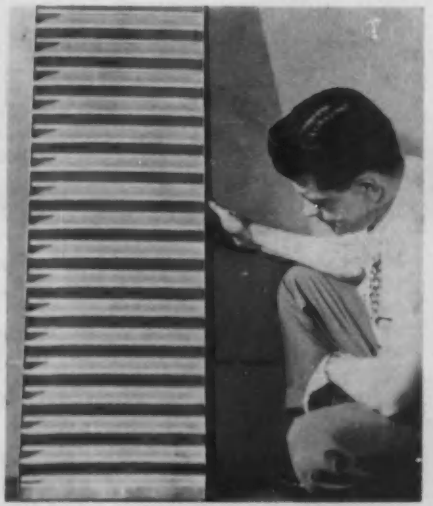

Fig. 2 — Sine wave wing spar is assembled by burn-through welding which joins the edge of a piece of sheet metal at 90 deg to the face of another.

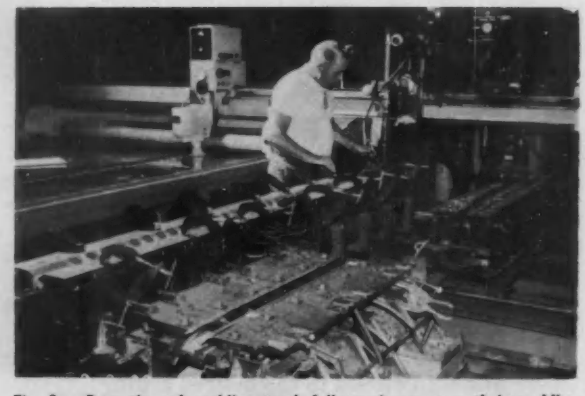

Fig. 3 — Burn-through welding torch follows sine wave path in welding sine wave edge to cap members.

techniques build B-70's

Based on paper by

Latham Pollock

North American Aviation, Inc.

Material drawn from
SAE Texas Section Paper

UNUSUAL, new fabricating techniques are being used on the Air Force 2000-mph B-70 Valkyrie. Among these are:

1. Sciaky boom and "burn-through" welding.
2. Brazed sleeve couplings.
3. "Skate" machining.

Welding operations

A sophisticated welding machine used in B-70 fabrication is the Sciaky boom welder (Fig. 1) which electronically controls arc length and senses the joint of two pieces to be welded.

Work is placed in appropriate welding fixtures around the boom welder which progresses from job to job. As each job is completed, it is removed and another project set up in its place. This arrangement provides continuous utilization of the equipment.

Another specialized type of welding required for the B-70 is "burn-through" welding. This operation joins the edge of a piece of sheet metal at 90 deg to the face of another. The welding torch is applied on the face opposite to that where the beads would normally be placed. The parent metal melts so that it forms a fillet with the edge of the adjoining member. Welding rod replaces the parent metal.

This process provides a lighter joint than conventional welding. It does, however, require greater accuracy in controlling the path of the welding head and more tooling. Since wave wing spars are a typical application (Fig. 2). These spars consist of three pieces of sheet metal — the two cap strips which are flat except for a return angle at each edge, and a web which is corrugated in the form of a sine wave. These corrugations run so that the sine wave edge welds to the cap members (Fig. 3).

In performing the burn-through weld which attaches these members, the welding torch follows a sine wave path. Appropriate tooling positions the cap in relation to the web, and the path of the weld torch is controlled by an electric eye sensing device following a sine wave template which corresponds to the shape of the spar web. When these spars are made of titanium rather than PH15-7 steel, it

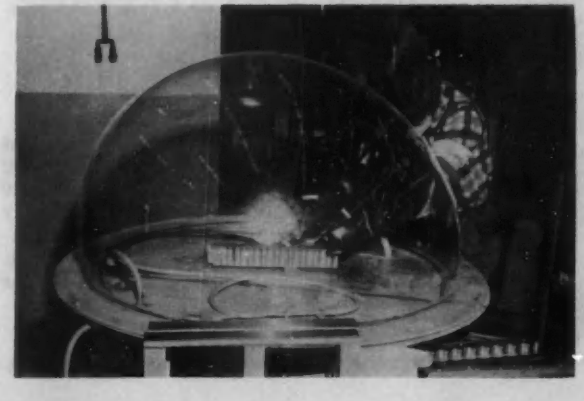

Fig. 4 — Welding titanium spar in argon-filled "bubble."

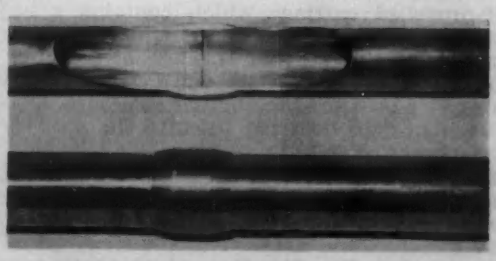

Fig. 5 — Brazed sleeve-type coupling for hydraulic lines on B-70.

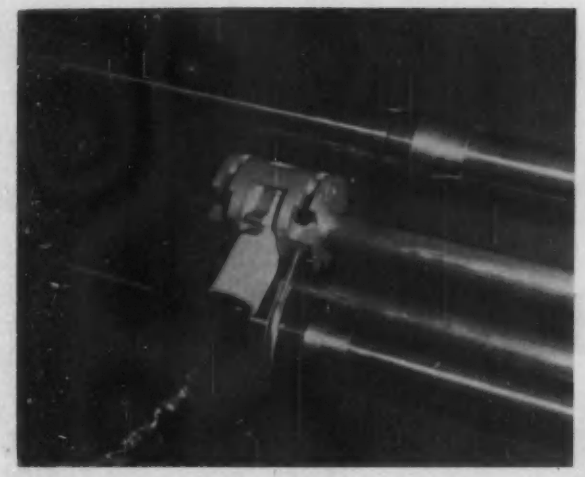

Fig. 6 — High-frequency heater supplies heat for brazing coupling.

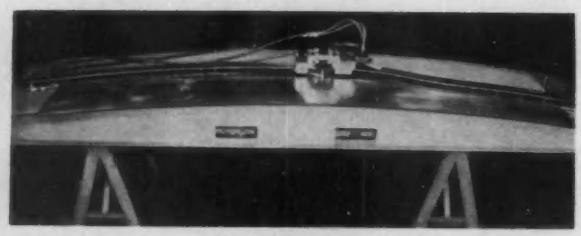

Fig. 7 — "Skate" machines attaching edges of structures prior to welding. Small self-propelled carriage contains cutting head.

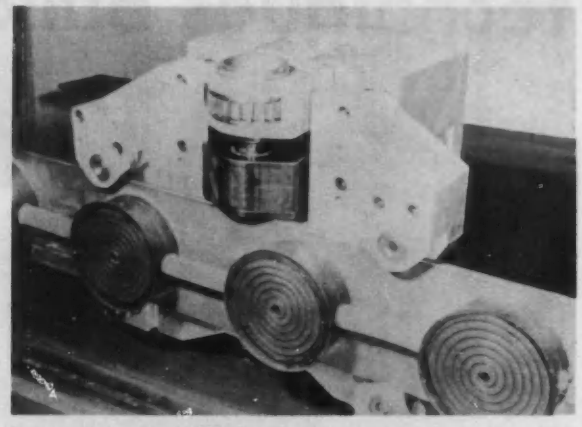

Fig. 8 — Underside of "skate" track contains vacuum cups for holding track to structure to be machined.

Sophisticated fabrication techniques build B-70's

. . . continued

is necessary to submerge the tools and the spar pieces in argon to provide consistent welds (Fig. 4).

Brazed couplings

The hydraulic system on the B-70 operates at about 4000 psi and 1000 F. Conventional compression couplings which will withstand these conditions are heavy compared to sleeve couplings. On the B-70, over 1000 lb is saved by using sleeve couplings. These couplings have two rings of silver brazing alloy placed into internal grooves located near each end of the sleeve. The tubes are inserted into the coupling, meeting at the center. A small recess at the center of the coupling breaks the capillary action of the brazing material and prevents it from flowing into the tubes (Fig. 5). Heat for the brazing operation is provided by a high frequency heater which is clamped around the coupling (Fig. 6).

Skate machining

"Skate operations" provide a suitable method of machining the attaching edges of structures prior to welding. The skate concept consists of a small self-propelled carriage which contains a cutting head (Fig. 7). This carriage travels on a track which is formed so that the line of travel of the skate will conform to the edge of the structure which is to be welded to another structure. A series of vacuum cups hold the track to the structure to be machined (Fig. 8).

The track is positioned with an appropriate amount of offset from the edge to be machined, so that as the skate moves down the track the cutting head will machine the edge of the structure to the desired point (Fig. 9). The other structure to be joined is positioned close to the structure which has been machined so that by just moving the cutting head the second structure can be machined. The track is not moved. Structures machined this way will match when moved together.

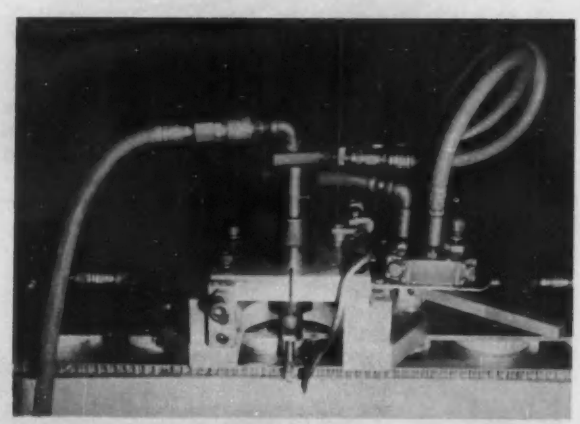

Fig. 9 — "Skate" machining edge of structure to be welded.

The skate concept has been expanded to perform welding operations (Fig. 10) and X-ray operations (Fig. 11), as well as machining.

To Order Paper No. S308 . . .
from which material for this article was drawn, see p. 6.

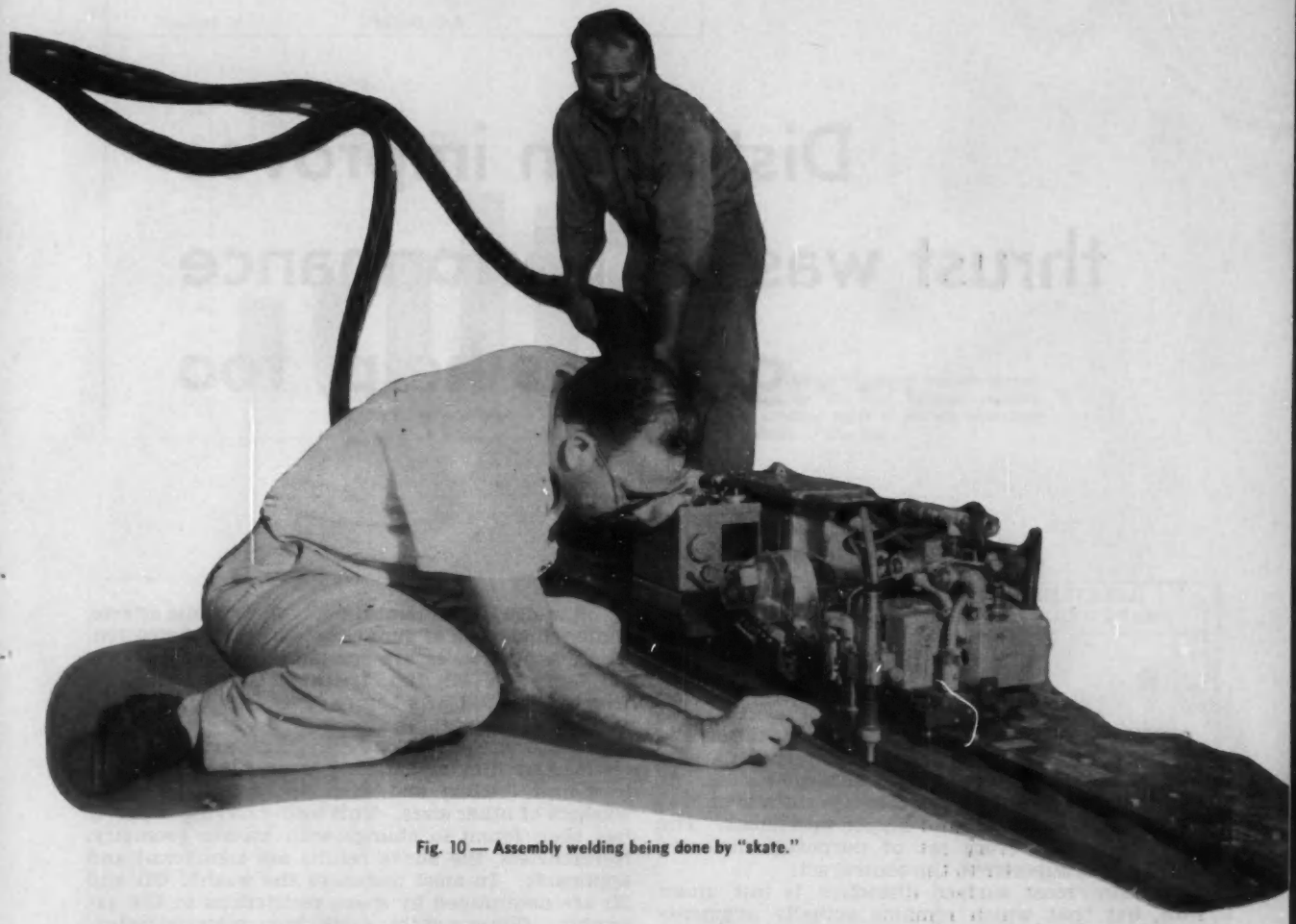

Fig. 10 — Assembly welding being done by "skate."

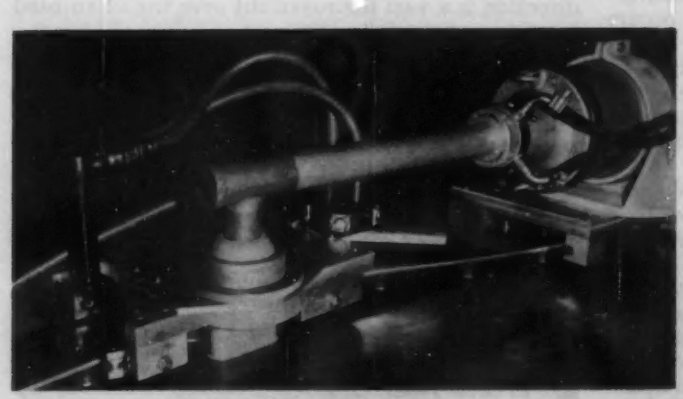

Fig. 11 — "Skate" performing x-ray operation on assembly weld.

Distortion improves thrust washer performance . . . grooves help, too

Based on paper by

William A. Weinkamer

Clevite Corp.

ADVOCATES of super-flat washers for automatic transmissions might do well to review flatness specifications in the light of recent test results. As Fig. 1 shows, the poorest washer performance was offered by the ground and lapped specimens. The performance of every set of purposely distorted washers was superior to the control set.

Actually, most surface distortion is lost under load, but that which remains actually augments performance by forming beneficial oil wedges.

According to theory, if a plain washer is perfectly flat, no load carrying capacity can be expected of it. However, surface waviness, resulting from fabrication, enables it to function under film, or "boundary," lubrication. This type of lubrication occurs when the bearing surfaces are separated by a thin film of an effective lubricant. The coefficient of friction under these conditions is somewhere between 0.050–0.100, although this may vary because of such factors as speed, temperature, and contaminants.

By adding grooves to the plain washer, thereby increasing oil flow across the washer surface, load carrying capacity is increased. Different types of grooving are shown in Fig. 2. The gains to be realized by using the different kinds of grooves are indicated in Fig. 3. The increased load carrying capacity over the plain washer of the thru grooves, teardrop grooves, and tapered land type, respectively, are 31%, 88%, and 300%. The large increase found with tapered land is due to the production of an oil wedge, accompanied by hydrodynamic effects. Under conditions of pure hydrodynamic lubrication, where the surfaces are completely separated by a very effective oil film, friction coefficients range from 0.001–0.010. As before, these values can vary with environment.

Unfortunately, the load-carrying capacity (based on load at film breakdown) cannot be translated into unit loading and then applied wholesale to washers of other sizes. Unit load-carrying capacity has been found to change with washer geometry. Nevertheless, the above results are significant and applicable. In most instances the washer OD and ID are determined by space restrictions in the assembly. Consequently, aside from material selection, the designer often has only a choice of groove design to offer for successful operation. Now, if trouble arises, he at least knows in what direction a solution can be found. An intelligent choice of direction is a vast improvement over the often used "scatter approach."

In many cases the thrust washer performs the multiple function of supporting load and restricting oil flow. Conversely, it may have to pass oil freely to other units through wide open grooves. As a result, thrust washer groove design is often compromised, with a resulting sacrifice of load carrying capacity. Under these conditions it would be wise to consider a combination groove design. For instance, a washer which must supply oil to a bushing could incorporate thru grooves for this purpose, in conjunction with teardrop grooves to improve load-carrying capacity. Otherwise, a thru groove which throttles the oil flow from inlet to outlet might be used.

To Order Paper No. 359E . . .
from which material for this article was drawn, see p. 6.

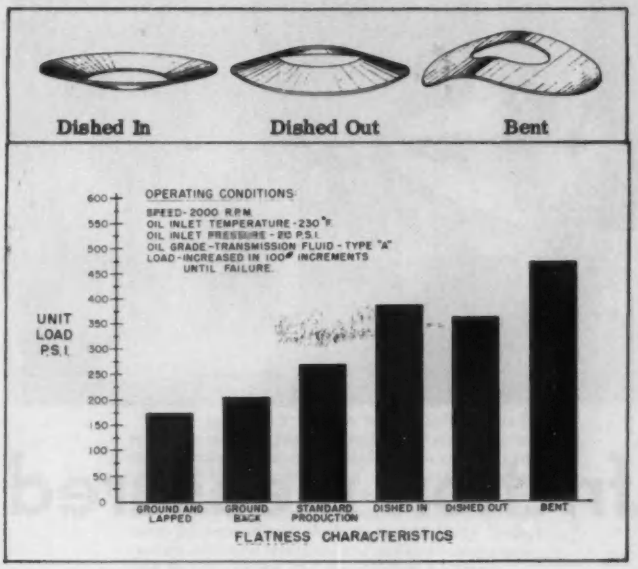

Fig. 1 — Effect of washer flatness characteristics on the load carrying capacity. The principal types of surface distortions are shown at the top.

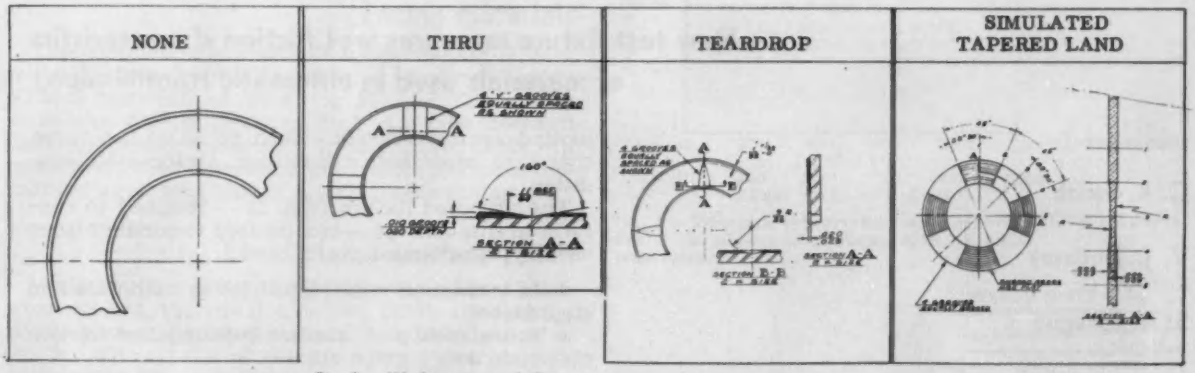

Fig. 2 — Washer groove designs.

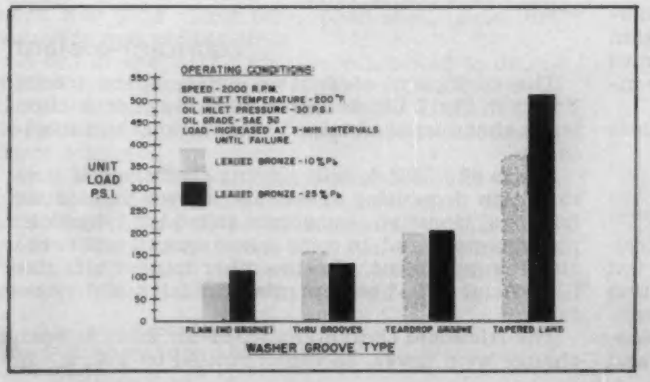

Fig. 3 — Effect of washer groove type on the load carrying capacity.

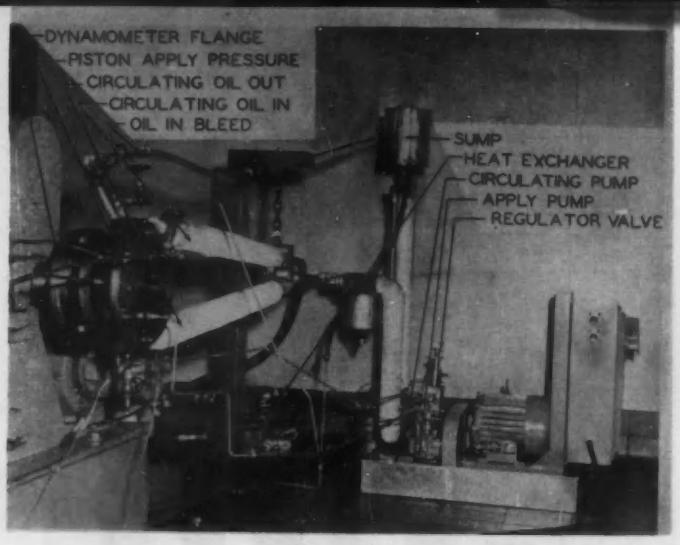

Fig. 1 — Typical SAE friction test fixture, shown installed on dynamometer, together with auxiliary equipment necessary to run a typical test.

Wet friction measured in steady-state test

New test fixture measures wet friction characteristics of materials used in automatic transmissions.

Based on paper by

G. R. Smith
General Motors Corp.

V. J. Jandasek
Ford Motor Co.

S. R. Sprague
Shell Oil Co.

and

R. B. Singer
Motec Industries

A STEADY-STATE test for measuring the wet friction characteristics of materials used in automatic transmissions is being developed by the Subcommittee on Friction of the SAE Transmission Committee. It is hoped that this test will prove more satisfactory than previous tests, such as the inertia dynamometer test.

With the new procedure, three important variables in the operation of transmissions can be fixed:

- Temperature.
- Velocity.
- Unit pressure.

Thus, test points can be taken at fixed pressures, at stabilized velocity, and with large volumes of test oil flowing over the interface of the grooved friction plate to control the temperature. Under these controlled conditions, test fixture torque can be measured, converted into coefficient of friction, and plotted against velocity. Each point on the curve, therefore, represents a stabilized, steady-state condition.

The proposed fixture (Fig. 1) — designed to conform to this concept — can be used to conduct three basic types of tests:

- To test an oil relative to friction materials and steel plates.
- To test steel plate surface finish against friction materials with a given oil.
- To test steel surfaces and oil against an unknown friction material.

To illustrate the practicability of the SAE test fixture in the study of design problems, the results of tests with different lubricants, facing materials, and surface finishes of the steel plates are presented below.

Lubricant-coolant

The coefficient of friction versus speed curves shown in Fig. 2 illustrate the wide range of friction levels that can be obtained with various test lubricants.

Fluids like RFF-4, with a rising coefficient of friction with decreasing speed, are known to promote frictional vibration (sometimes called the "slipstick" phenomenon) and, in some cases, squawk and rough clutch engagement. On the other hand, fluids like RFF-1 and RFF-3 tend to minimize frictional vibrations.

The frictional characteristics of the lubricant can change with usage, as demonstrated by Fig. 3. In

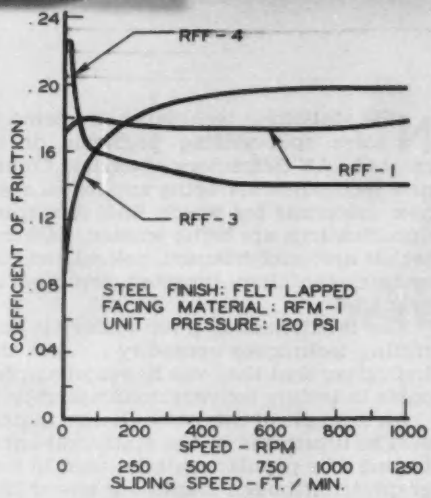

Fig. 2 — Differences between lubricant-coolants. RFF-1 and RFF-3 contain highly surface-reactive materials, which prevent or modify surface-to-surface contact occurring during boundary lubrication conditions and thereby reduce the coefficient of friction. RFF-4 contains no friction modifying agent, so the coefficient of friction increases with decreasing speed because of loss of oil wedge tendency. It does contain oxidation inhibitors and antiwear agents common to both engine and transmission lubricants.

this case, a definite change in the shape of the friction curve favoring frictional vibration and an increase in the static coefficient of friction from 0.08 to 0.14 was observed.

Facing materials

The commercially available asbestos-base RFM-1 material was compared with a sintered-bronze RFM-2 material, as shown in Fig. 4. The curves show the wide differences that can exist between different facing materials. In the future, tests will be conducted to determine the frictional characteristics of a resilient type of clutch facing material.

Steel plates—surface finish

Various commercial methods of surface finish were studied, including a lapped finish (fine abrasive), a microhoned finish, and a roller burnish finish. The results of these studies, together with proficorder traces indicating comparative asperity heights, are shown in Fig. 5.

These results indicate that the smoother the finish, as measured by decrease in asperity height, the lower the kinetic coefficient of friction. Static friction levels were also sensitive to surface finish, although to a lesser extent. Most of the committee work was done using felt-lapped steel plates obtained from a single source.

A few of the tests were also conducted to determine the influence of gross contour waves, which extended across 30–60% of the width of the plate. These results suggested a 5–10% overall reduction in friction level.

It is evident that the surface finish of the steel plate has a definite influence on coefficient of friction when tested with the friction materials indicated. There is evidence, however, that with certain other friction materials the surface finish of the steel plate has relatively little effect.

To Order Paper No. 363A . . .
from which material for this article was drawn, see p. 6.

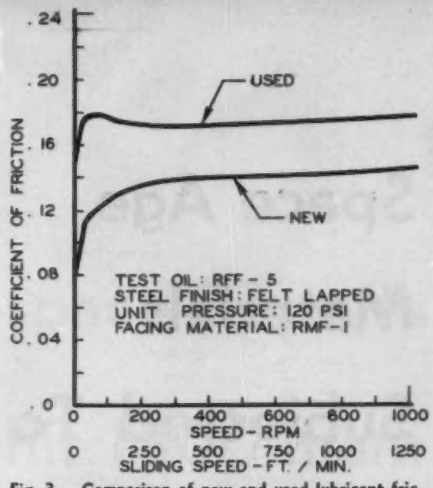

Fig. 3 — Comparison of new and used lubricant friction characteristics.

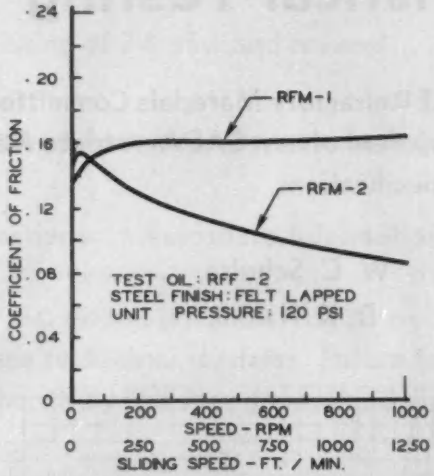

Fig. 4 — Difference between two facing materials. RFM-1 has asbestos base, whereas RFM-2 is a sintered bronze.

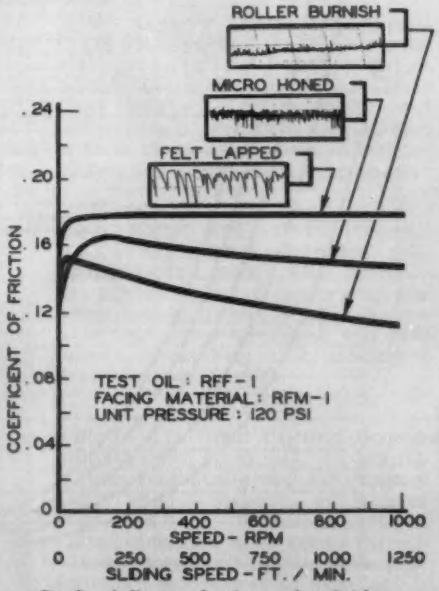

Fig. 5 — Influence of various surface finishes.

Space Age Materials Subjected To Statistical Testing

... by SAE Refractory Materials Committee in development of new SAE Aerospace Materials Specifications.

Based on report by **W. C. Schulte,** Curtiss-Wright Corp.
and **D. K. Hanink,** Allison Division, GMC

NEW statistical techniques are being used to help solve spec-writing problems of the recently created SAE Refractory Materials Committee. The new techniques are being applied to a wide range of new materials for which SAE Aerospace Materials Specifications are being written. Among these materials are: molybdenum, columbium, titanium, vanadium, tantalum, tungsten, ceramics, cermets, and graphite.

The brittleness of these materials made the new testing techniques necessary . . . but there is every indication that they will be found helpful and applicable to testing conventional materials later on.

An example of this basic change in philosophy can best be illustrated by the statistical approach in the testing of a popular material used in rocket nozzles, graphite. Although graphite is one of the oldest materials, the name itself belies the great variety of grades and types which are produced in the industry. It's a double specification problem of dealing with a brittle material while simultaneously attempting to differentiate material by other than composition.

For example, the test methods employed for flexural strength, compressive strength, and tensile strength are all ASTM standards for concrete and/or cement mortars. Certainly, these seem to temporarily "fill the bill," but this serves to emphasize the type of structural material with which we must cope on certain space age specialized applications. On physical properties, it may become common place to measure Young's Modulus using sonic techniques in a routine manner whereas such apparatus has been largely confined to the research laboratory.

Vehicle Reliability Linked to New Testing Techniques

"How many parts in 1000 will fail?" is a question that will be answered more directly by using the new statistical techniques in AMSs. Right now the Weibull Theory of Strength shows immediate promise of giving direct reliability figures on materials with a minimum of testing. This is because:

- Results of strength tests for one stress state can be used to determine average failure stresses in other stress states.
- Effects due to size can be determined theoretically.
- The Weibull material constant, *m*, doesn't vary with stress state.

An example of the use of this last point is shown in Fig. 1. Each material has a characteristic *m* value (bare Type I graphite at room temperature has an *m* of about 6 while mild steel is about 58). From the graph the Material Safety Factor can quickly be established for the probability in question. This gives the designer data in a form compatible with his need for reliability information.

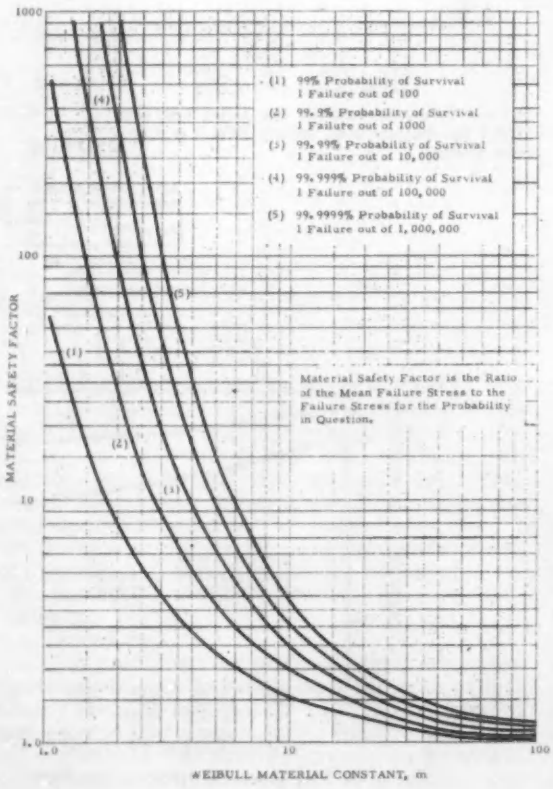
(1) 99% Probability of Survival
1 Failure out of 100
(2) 99.9% Probability of Survival
1 Failure out of 1000
(3) 99.99% Probability of Survival
1 Failure out of 10,000
(4) 99.999% Probability of Survival
1 Failure out of 100,000
(5) 99.9999% Probability of Survival
1 Failure out of 1,000,000
Material Safety Factor is the Ratio of the Mean Failure Stress to the Failure Stress for the Probability in Question.
MATERIAL SAFETY FACTOR
WEIBULL MATERIAL CONSTANT, m
1000
100
10
1.0
1.0
10
100

Fig. 1 — **The variation of material safety factor** with Weibull material constant, **m**, for various probabilities of survival.

SAE Aerospace Reports hit 1300 mark

This digest-listing of 74 new and revised . . .

• Aerospace Standards • Aerospace Recommended Practices

• Aerospace Material Specifications • Aerospace Information Reports

. . . constitutes part of a new service to Journal readers. Future listings will cover all reports approved each month by the four ground and air Councils of the SAE Technical Board.

THIS is the second digest-listing of new and revised SAE reports to appear as a monthly service to SAE Journal readers. It consists of the 74 aerospace reports approved by the Aerospace Council of the SAE Technical Board since January, 1961. (The first began last month with a preview of new and revised ground vehicle reports scheduled for the 1962 SAE Handbook.)

Next month's listing will cover what was approved within the previous month by the four ground and air Councils.

Issuance of the 37 new reports listed herein has pushed SAE's existing family of aerospace documents to the 1300 mark.

Aerospace Council

Carl Sadler
Chairman

NEW: **SAFETY (LAP) BELTS FOR CIVIL TRANSPORT AIRCRAFT (ARP 682)** — Contains recommendations leading to standardization of safety (lap) belts in civil transports. All components of the belt, except for seat or berth structure, are covered. (Committee S-9, Cabin Safety Provisions)

REVISED: **AIR CONDITIONING, HELICOPTERS, GENERAL REQUIREMENTS FOR (ARP 292A)** — Extensively revised to concur with the latest state-of-the-art as it has evolved since 1954 when the report was first issued. (Committee A-9, Aerospace Environmental Systems)

REVISED: **AIR CONDITIONING EQUIPMENT, GENERAL REQUIREMENTS FOR SUBSONIC AIRPLANES (ARP 85A)** — Updated to present state-of-the-art. Reflects experience gained since 1956 in operating current subsonic transports. (Committee A-9, Aerospace Environmental Systems)

(continued on next page)

NEW: **THERMAL DESIGN CONCEPTS FOR HIGH MACH NUMBER AIRCRAFT (ARP 728)** — Will help electronic manufacturers select design approach to equipment which can operate in supersonic environment. General design concepts, considered to be minimum acceptable standards for use in electrical and electronic equipment are outlined. The report is aimed at increasing equipment reliability without penalizing performance. (Committee A-9, Aerospace Environmental Systems)

REVISED: **LOW-PRESSURE HIGH-TEMPERATURE PNEUMATIC DUCTING SYSTEMS — 300 PSI AND 1000 F MAXIMUM (ARP 699A)** — A field maintenance and inspection section has been added. (Committee A-9, Aerospace Environmental Systems)

NEW: **OXYGEN EQUIPMENT, PROVISIONING AND USE IN HIGH ALTITUDE (TO 40,000 FT.) COMMERCIAL TRANSPORT AIRCRAFT (AIR 505)** — Will help industry in selection and usage of oxygen equipment for high-altitude transports flying between 8,000 and 40,000 ft. (Committee A-10, Aircraft Oxygen Equipment)

REVISED: **COCKPIT VISIBILITY REQUIREMENTS FOR COMMERCIAL TRANSPORTS AIRCRAFT (ARP 580A)** — Defogging and Precipitation removal Sections were clarified. (Committee S-7, Cockpit Standardization)

NEW: **COLOR CODING OF TERMINALS AND WIRING FOR FLIGHT EQUIPMENT (ARP 669)** — Provides a color code guide for identifying 3-phase electrical wiring and terminals of flight equipment. This code is intended to supplement other identification practices such as MIL-STD-122, MIL-STD-195, MIL-SPEC.-5088B. Selected colors conform with MIL-STD. 195 for marking connections for electrical assemblies. (Committee A-2 Aerospace Electrical Equipment)

NEW: **FUEL AND OIL QUANTITY INSTRUMENTS-TURBINE POWERED SUBSONIC AIRCRAFT (AS 445)** — Establishes essential miminum safe performance standards for fuel and oil quantity instruments subjected to the environmental conditions of turbine-powered subsonic transports and is applicable to the capacitance sensor type of instrument. (Committee A-4, Aircraft Instruments)

REVISED: **POWERPLANT FIRE DETECTION INSTRUMENTS — THERMAL AND FLAME CONTACT TYPES — RECIPROCATING ENGINE POWERED AIRCRAFT (AS 401B)** — Updated to meet current requirements of state-of-the-art. (Committee A-4, Aircraft Instruments)

REVISED: **MAXIMUM ALLOWABLE AIRSPEED INSTRUMENTS — RECIPROCATING ENGINE POWERED AIRCRAFT (AS 418A)** — Up-dated to meet current requirements of state-of-the-art. (Committee A-4, Aircraft Instruments)

NEW: **TEMPERATURE INSTRUMENTS — TURBINE POWERED SUBSONIC AIRCRAFT (AS 414)** — Establishes essential minimum safe performance standard for electrical-type temperature instruments primarily used on turbine-powered, subsonic transports. Ratiometer and millivoltmeter type instruments are covered. (Committee A-4, Aircraft Instruments)

NEW: **LIGHTING, INTEGRAL, FOR AIRCRAFT INSTRUMENTS: CRITERIA FOR DESIGN (ARP 582)** — Recommends basic considerations and criteria to be observed by designers of integral instrument lighting systems. Covers general requirements and test procedures for lighting systems which are to provide uniform lighting of each instrument and give good legibility under day or night conditions as well as between instrument displays. (Committee A-20, Aircraft Lighting)

NEW: **LANDING AND TAXIING LIGHTS — CRITERIA FOR INSTALLATION (ARP 693)** — Recommends criteria for the design of landing and taxiing light systems. Covered are requirements for installations in single-engine personal, light twin-engine, large, multi-engine propeller and turbo-jet, military high-performance fighter and attack aircraft, and helicopter. (Committee A-20, Aircraft Lighting)

NEW: **AIRCRAFT AIR COMPRESSOR LUBRICATING OIL (ARP 664)** — Sets forth uniform requirements for a grade of oil used in a high-pressure compressor with self-contained lubricating systems. Since such an oil is not yet available, the report is intended to serve as a guide for its development. (Committee A-6, Aerospace Hydraulic and Pneumatic Systems and Equipment)

REVISED: **HOSE ASSEMBLIES: AIRCRAFT AND MISSILES, HIGH-TEMPERATURE, HIGH-PRESSURE (250,000 CYCLES) (ARP 604A)** — Covers hose assemblies suitable for use in high-temperature (400 F), high-pressure (3000 psi), high impulse life aircraft and missiles fluid applications. (Committee G-3, Aerospace Fittings and Flexible Hose Assemblies)

NEW: **SUGGESTED PHYSICAL AND PERFORMANCE TESTS FOR TYPE II (−65 to +275 F) O-RING PACKINGS, 3000 PSI PNEUMATIC SERVICE (AIR-740)** — Outlines test methods proposed for qualifying O-ring packings used in aircraft pneumatic systems. The report is a basis for future preparation of a complete packings specification, the latter being considered feasible only after it becomes known what basic type of elastomer proves capable of desired performance. (Committee G-4, Elastic Seals)

NEW: **AIRCRAFT CONSTANT DISPLACEMENT HYDRAULIC MOTOR (AS 696)** — Establishes common requirements for constant-displacement hydraulic motors and provides methods of demonstrating compliance with with these requirements. Committee A-6, Aerospace Hydraulic and Pneumatic Systems and Equipment)

NEW: **SUPPORT EQUIPMENT ENGINEERING DATA SHEET (ARP 706)** — Provides a format for presenting technical information on commercially-available aerospace support equipment. Is similar to a form used by Air Force and Navy to describe support equipment. Developed for potential users of support equipment. (Committee GSE-1)

NEW: **BEARING, BALL, ANNULAR (ARP 671)** — Provides certain design requirements and quality assurance provisions for anti-friction bearings used by aircraft industry. Covers single-row, radial, deep-groove, non-filling, slot-type ball bearings having tolerance grades 1, 3, 5, and 7, and varying radial clearances. (Committee E-25, Engine and Propeller Standard Utility Parts)

REVISED: **TUBE BENDING RADIUS (AS 130A)** — Completely revised. This report now contains a monogram for easy selection of minimum bend radius for this class of tube bending. (Committee E-21, Design and General Standards for Aerospace Propulsion Systems)

NEW: **ANALYSIS AND RECOMMENDATIONS OF GOOD PRACTICE FOR TURBO-JET AIRCRAFT ENGINE TEST CELL CORRELATION (AIR 741)** — Outlines practices and procedures leading to better correlation of performance tests used in development and acceptance of turbo-jet engines. Key aspects of reproducible engine performance are covered. (Propulsion Test Study Panel)

REVISED: **PREMIUM AIRCRAFT QUALITY STEEL CLEANLINESS — Magnetic Particle Inspection Procedure (AMS 2300A)** — Changes affect *sampling procedures* plus *rough machining* and *heat treatment* parts of Specimen Preparation Section.

Aerospace Material Specifications

REVISED: **AIRCRAFT QUALITY STEEL CLEANLINESS — Magnetic Particle Inspection Procedure (AMS 2301A)** — Revisions occur only in Disposition Section.

REVISED: **NICKEL-ZINC ALLOY PLATING (AMS 2417A)** — A change occurs in the *hydrogen embrittlement relief* part of Technical Requirements Section.

NEW: **PLATING MAGNESIUM FOR SOLDERABILITY — Zinc Immersion Process (AMS 2421)** — For preparing magnesium parts for soft soldering.

REVISED: **SHOT PEENING (AMS 2430C)** — Changes occur in sections on: Peening Designation; Material and Equipment; and Approval.

REVISED: **ALUMINUM BRAZING (AMS 2672B)** — Extensive revision of Process Requirements and Approval Sections.

NEW: **LEAK TEST SOLUTION — Liquid Oxygen Compatible (AMS 3159)** — For use in detecting leaks in liquid oxygen propulsion systems where a leak test solution (bubble fluid) is desirable.

REVISED: **SILICONE RUBBER — 1000 psi (45–55) (AMS 3345A)** — Extensive revisions affect physical properties. Changes also in Application, Tolerance, Reports, and Approval Sections.

REVISED: **HOSE, SYNTHETIC RUBBER, AIRCRAFT FUELING — Textile Reinforced, Collapsing (AMS 3386A)** — Revision affects *cover* part of Material and Lubrication Section; *burst pressure* part of Technical Requirements Section, and Standard Sizes, Weights, and Tolerances Section.

REVISED: **HOSE, SYNTHETIC RUBBER, AIRCRAFT FUELING — Textile Reinforced, Noncollapsing (AMS 3387A)** — Revisions affect same Sections shown in AMS 3386A.

REVISED: **HOSE, SYNTHETIC RUBBER, AIRCRAFT FUELING — Single Wire Braid Reinforced, Noncollapsing (AMS 3388A)** — Revisions affect sections on: Material and Fabrication; Technical Requirements; and Standard Sizes, Weights, and Tolerances.

REVISED: **HOSE, SYNTHETIC RUBBER, AIRCRAFT FUELING — Double Wire Braid Reinforced, Noncollapsing (AMS 3389A)** — *Hose* and *cover* parts of Material and Fabrication Section are affected along with *burst pressure* part of Technical Requirements Section. Changes also occur in Standard Sizes, Weights, and Tolerances Section.

NEW: **PLASTIC MOLDINGS AND EXTRUSIONS — Polyamide — Nylon (AMS 3617)** — For mechanical parts requiring high strength and resistance to aircraft fuels and lubricants at temperatures up to 250 F.

REVISED: **PLASTIC EXTRUSIONS, FLEXIBLE — Polyvinyl Chloride (AMS 3630C)** — *Appearance* and *properties* parts of Technical Requirements Section have changed. Also revised were Tolerances Section and a portion of Approval Section.

NEW: **PLASTIC MOLDINGS, LAMINATED, THERMOSETTING RESIN — Glass Fabric Reinforced, Heat Resistant — 500 F (AMS 3642)** — For parts requiring thermal stability when in continuous service at temperatures up to 500 F or intermittent service up to 1000 F consistent with good mechanical properties.

NEW: **SANDWICH STRUCTURES, GLASS FABRIC-RESIN — Low Pressure Molded, Heat Resistant (AMS 3710)** — For structural and electrical parts requiring low weight and high strength properties at temperatures up to 300 F.

NEW: **POLYTETRAFLUOROETHYENE SHEET — TFE Fluorocarbon Resin, Asbestos Fiber Reinforced (AMS 3842)** — For gaskets requiring a minimum of thickness variation and compatibility with liquid oxygen.

NEW: **ASBESTOS FELTING — "B" Stage Phenolic Resin Impregnated Low-Pressure Molding (AMS 3858)** — For molding into flat sheets and contoured laminates requiring resistance to continuous exposure up to 500 F or short time (i.e. ½ hr or less) exposure up to 600 F.

NEW: **CRYSTALLIZED GLASS CERAMIC (AMS 3880)** — For high-temperature, high-frequency applications in the electronics field, such as radomes, microwave antennas, and antenna covers.

REVISED: **ALUMINUM ALLOY SHEET AND PLATE — 4.5Cu — 0.8Si — 0.5Mg (2014–0) (AMS 4028A)** — Certain tensile property requirements have changed.

REVISED: **ALUMINUM ALLOY SHEET AND PLATE — 4.5Cu. — 0.8Si — 0.8Mn — 0.5Mg (2014–T6) (AMS 4029A)** — Tensile property requirements have changed.

REVISED: **ALUMINUM ALLOY SHEET AND PLATE — 4.5Mg — 0.65Mn — 0.15Cr (5083–0) (AMS 4056A)** — The Tensile Properties and Protective Treatment Sections have changed.

REVISED: **ALUMINUM ALLOY SHEET AND PLATE — 4.5Mg — 0.65Mn — 0.15Cr (5083–H113) (AMS 4059A)** — Tensile Properties and Protective Treatment Sections have changed.

REVISED: **ALUMINUM ALLOY EXTRUSIONS — 0.65Mg — 0.4Si (6063–T6) (AMS 4156C)** — Changes occur in Tensile Properties and Identification Sections.

REVISED: **MAGNESIUM ALLOY SHEET AND PLATE — 3.2Th — 0.7Zr (HK31A-H24) (AMS 4385B)** — Tensile and Compressive Properties, Tolerances, and Identification Sections have changed.

REVISED: **MAGNESIUM ALLOY SHEET AND PLATE — 2Th — 0.8Mn (HM21A-T8) (AMS 4390A)** — Revisions affect Condition, Tolerances, and Identification Sections.

NEW: **MAGNESIUM ALLOY CASTINGS, SAND — 2.5Ag — 2Di — 1Zr (QE22A-T6) — Solution and Precipitation Heat Treated (AMS 4418)** — For parts requiring high yield strength at temperatures up to 600 F.

NEW: **MAGNESIUM ALLOY CASTINGS, INVESTMENT — 10A1 (AM100A-T6) — Solution and Precipitation Heat Treated (AMS 4455)** — For small and intricate parts, operating at temperatures up to 300 F, cast to approximately final dimensions where the intricacy of the part is such that a high fluidity is required.

REVISED: **TITANIUM ALLOY — 6A1 — 4V — Annealed, 120,000 psi Yield (AMS 4928A)** — The *hardness* and *properties after heat treatment* parts of the Technical Requirements Section have changed as well as the Composition, Tolerances, and Identification Sections.

REVISED: **STEEL CASTINGS, SAND AND CENTRIFUGAL, CORROSION RESISTANT — 16Cr — 4Ni — 2.9Cu (AMS 5398A)** — Revision affects Composition, Condition, Technical Requirements, and Reports Sections.

(continued on next page)

NEW: STEEL SHEET AND STRIP, CORROSION RESISTANT — 12.5Cr (SAE 51410 Modified) — Ferrite Controlled (AMS 5505) — For parts and assemblies requiring uniformly high room-temperature tensile properties along with oxidation resistance up to 1000 F where control of ferrite content is necessary.

REVISED: STEEL SHEET AND STRIP, CORROSION RESISTANT — 18Cr — 8Ni (SAE 30302) — Deep and Shallow Forming — (AMS 5515D) — Revision changes Applications, Condition, and Identification Sections.

NEW: STEEL TUBING, WELDED, CORROSION AND HEAT RESISTANT — 20Cr — 9Ni — 1.4Mo — 1.4W — 0.4(Cb + Ta) — 0.2Ti — Thin Wall (AMS 5579) — For high-temperature air ducting requiring both corrosion and heat resistance, wherein the wall thickness is approximately 2% of the OD or less.

REVISED: STEEL TUBING, SEAMLESS, CORROSION RESISTANT — 12.5Cr (SAE 51410) (AMS 5591D) — Composition Section revised.

NEW: STEEL, CORROSION AND MODERATE HEAT RESISTANT — 12.5Cr (SAE 51410 Modified) — Ferrite Controlled (AMS 5612) — For parts and assemblies requiring uniformly high temperature tensile properties along with oxidation resistance up to 1000 F where control of ferrite content is necessary.

REVISED: STEEL, CORROSION AND MODERATE HEAT RESISTANT — 12.5Cr (SAE 51410) (AMS 5613E) — Two Sections were revised: Composition and Condition.

REVISED: ALLOY, CORROSION AND HEAT RESISTANT — Nickel Base — 22Cr — 1.5Co — 9Mo — 0.6W — 18.5Fe (AMS 5754D) — The *check analysis* part of Composition Section was corrected to read: "Composition variations shall meet the requirements of the latest issue of *AMS 2269*."

REVISED: ALLOY, CORROSION AND HEAT RESISTANT — Cobalt Base — 20Cr — 10Ni — 15W (AMS 5759B) — The *hardness* part of Technical Requirements Section was changed as were the Tolerances and Reports Sections.

NEW: STEEL WIRE, WELDING, CORROSION AND HEAT RESISTANT — 15Cr — 26Ni — 1.3Mo — 2.2Ti — 0.3V (AMS 5804) — For use as filler metal for inert gas arc welding of precipitation hardening corrosion resistant steels of similar composition.

REVISED: STEEL WIRE, WELDING, CORROSION AND MODERATE HEAT RESISTANT — 15Cr — 7.1Ni — 2.4Mo — 1Al — Vacuum Melted (AMS 5812A) — The *cast* part of Technical Requirements was changed.

NEW: STEEL WIRE, WELDING, CORROSION RESISTANT — 12.5Cr (SAE 51410 Modified) — Special Grade (AMS 5821) — For use as filler material for welding corrosion resistant alloys of similar composition which have requirements for control of ferrite.

NEW: HONEYCOMB CORE, CORROSION AND HEAT RESISTANT STEEL — Resistance Welded — Square Cell (AMS 5850) — For use as a low-density material in brazed structures.

NEW: STEEL — 0.95Cr — 0.2Mo (0.38–0.45C) (SAE 4140 Modified) — Die Drawn and Tempered, 130,000 psi Yield (AMS 6378) — For parts such as shafts, axles, pins, fasteners, gears, and screw machine parts which are normally used at hardness of Rockwell C 30–36.

NEW: STEEL — 0.95Cr — 0.2Mo (0.40–0.53C) (SAE 4140 Modified) Die Drawn and Tempered, 165,000 psi Yield (AMS 6379) — For parts such as shafts, axles, pins, gears, and screw machine parts which are normally used at hardness of Rockwell C 37–43.

NEW: STEEL SHEET AND PLATE — Low Alloy, Heat Treated — 100,000 psi Yield Strength (AMS 6386) — For large structural applications requiring a good combination of strength, formability, and weldability without subsequent heat treatment.

NEW: STEEL — 1.6Si — 0.8Cr — 1.8Ni — 0.07V (0.41–0.46C) (AMS 6416) — For heat treated parts, such as pressure vessels, requiring through hardening to high-strength levels. May be welded without undue difficulty.

REVISED: ALUMINUM RIVETS — 99Al (1100-H14) (AMS 7220C) — Composition has changed.

REVISED: ALUMINUM RIVETS — 2.5Cu — 0.3Mg (2117-T4) (AMS 7222C) Composition has changed.

REVISED: DECALCOMANIAS (AMS 7290B) — *Mounting instructions* and *material* parts of Technical Requirements Section have changed . . . as has a part of the Approval Section.

NEW: VIRGIN BERYLLIUM BARS, RODS, AND SHAPES (AMS 7900) — For parts requiring high strength-to-weight ratio and high modulus of elasticity.

NEW: BERYLLIUM BARS, RODS, AND SHAPES (AMS 7901) — For parts requiring high strength-to-weight ratio and high modulus of elasticity.

NEW: BERYLLIUM SHEET AND PLATE (AMS 7902) — For parts requiring high strength-to-weight ratio and high modulus of elasticity.

Preignition Mechanism

Based on paper by

H. V. LOWTHER and K. C. KRESGE

Socony Mobil Oil Co., Inc.

PREIGNITION in 2-stroke outboard engines running under extended high-speed, full-load conditions may well be of the hot-spot type. At least the preignition occurring in a 2-stroke engine operating in the laboratory under such strenuous conditions (Tables 1 and 2) appeared to be of this type, rather than of the deposit-induced variety, such as is usually found in passenger-car engines.

Here in further detail is a possible explanation of how this type of preignition may occur.

Table 1 — Specifications for 2-Stroke V-4 Engine

Displacement, cu in.	70.7
Bore × Stroke, in.	3 × 2½
Cooling System	Thermostat controlled, water cooled
Output, bhp at rpm	50 at 4000
Fuel Consumption (approx.) gal/hr	6.0

Table 2 — Test Conditions

Test Duration, hr	100
Test Cycle	
At Idle (550 ± 50 rpm), min	5
At Wide-Open Throttle (4850 ± 150 rpm), min	55
Jacket Water Temperature, F	140
Test Tank Water Temperature, F	100
Fuel/Oil Ratio	20/1

How Preignition Occurs

As the clean engine runs and begins to accumulate combustion-chamber deposits, these deposits tend to insulate the chamber and hinder heat conduction to the coolant. As a result the chamber surface — or, more correctly, the deposit surfaces — become extremely hot. This is aggravated, of course, by the characteristics of the two-stroke cycle and the severe engine test conditions: (1) one power stroke per cylinder for each revolution and (2) extended periods of high-output

operation. The deposits consists mainly of complex salts of lead, phosphorus, halogens, and oil additive metals. Due to high temperatures, there is little or no carbon present — usually less than 2%.

These deposits build up to the point where they break off, due to thermal shock or to mechanical force. Most of this debris leaves the chamber with the exhaust gases. However, small particles find their way to the spark-plug insulator tip, which is one of the hottest parts of the combustion chamber. Here the deposits accumulate enough heat to autoignite the fuel-air mixture and preignition results. Spark-plug insulator tip temperatures were about 1800 F with thermocouple plugs. Since this is an average running temperature for the cycle, peak temperatures should be significantly higher. They should, therefore, extend almost to the autoignition temperature of the fuel-air charge.

Anything that affects the combustion chamber in such a way as to reduce heat outflow even slightly should tend to push the temperature of the insulator tip above the autoingnition point of the fuel-air charge, resulting in preignition.

To prove that deposits on the plug were the preignition source, plugs in cylinders that were undergoing preignition were replaced with new plugs and, as a result, preignition stopped. When the used plugs were again put in the engine it immediately went into preignition.

Thus, it can be seen why phosphorus and lead are detrimental. Both tend to increase the amount of deposit formed. In addition, by forming less volatile salts with lead, phosphorus would interfere with the action of the halogen scavengers. Introducing large amounts of additional halogen scavengers reduces deposit formation, which in turn increases heat outflow and lowers preignition rates.

Likewise, detergents have an effect, since they can contribute to deposit buildup. This might suggest that an ashless detergent would be best. However, use of this type of material resulted in short plug life, due to spark-plug fouling. The presence of a metal such as calcium or barium, which will aid in forming highly electrically resistant deposits, is helpful in preventing or reducing spark-plug fouling. Unfortunately, components that aid in preventing fouling seem to be the same ones that aggravate preignition.

It is difficult to explain why more volatile base stocks cause less preignition, in view of the lack of carbon in the deposits. One possibility is that the more volatile, light distillates cause less porous deposits, that is to say a smaller volume of deposits, than the heavier stocks, and thus allow better heat conduction. Formation of carbon in the deposits during cooler portions of the cycle could occur with subsequent burn-off during the combustion portion. Thus, the carbon forming tendencies of oils could be a factor without leaving carbonaceous deposits. However, this is speculation and further study is needed to establish the validity of this assumption.

Any other factors tending to reduce the temperature of the spark-plug tip, such as lower-heat-range spark plugs, better cooling of the insulator tip through proper placement of the intake charge flow pattern, or better overall cooling of the cylinder-piston area, will tend to reduce preignition.

The preignition mechanism being discussed here is different from the preignition mechanism that, it is believed, is the usual case found in passenger-car engines. The basic distinction is in the severity of the service under consideration. Passenger-car engines generally are not run at full load for any length of time, whereas the outboard equipment under consideration is very frequently run for long periods of time at full load. This results in very high combustion-chamber temperatures, which is indicated by the fact that combustion chamber deposits contain very little carbon and are composed mainly of inert ash.

On the other hand, four-stroke-cycle operation at part load usually results in combustion-chamber deposits containing quite large amounts of carbon. This carbon appears to be the functional point of the phosphorus, as it is used in preventing or suppressing preignition in the four-stroke engine. The phosphorus, in this case, raises the glow point of the carbonaceous deposits and thus eliminates another source of ignition other than a spark itself. But, in the high-speed, high-output two-stroke application, where very little carbon is available, phosphorus tends to add to the amount of deposits, and in this way tends to insulate the combustion chamber even further from the cooling system. This raises the overall temperatures involved and, under certain critical conditions, temperatures are reached at the autoignition point of the fuel-air charge, resulting in hot-spot preignition. In other words, the point is that either type of engine, two-stroke or four-stroke, could, under the right conditions, have hot-spot preignition. Thus it appears that the preignition problem discussed here can be distinguished from the normal deposit-induced preignition occurring in passenger-car engines by the fact that there is a large difference in combustion-chamber temperatures involved in the two problems.

Table 3 — Effect of Modifications in Fuel and Oil in Preignition and Spark-Plug Fouling

Component Change	Preignition	Spark-Plug Fouling
Remove tel from fuel	Decreases	Decreases
Remove phosphorus from fuel	Decreases	Decreases
Remove phosphorus from oil	Decreases	Decreases
Decrease oil ash content	Decreases	Increases
Replace metallic detergent with ashless detergent	Decreases	Increases
Use light distillate base stocks	Decreases	No change
Use halide scavenger agents	Decreases	Decreases

Reference Fuel = Gasoline with 22 ppm of phosphorus and 3.0 ml/gal of tel
Reference Oil = SAE 30 outboard oil with 30% bright stock, a metallic detergent, and a phosphorus-sulfur inhibitor-antiwear agent

Effect of Changing Fuel and Oil Components

To summarize the test results, Table 3 has been compiled to show the effect of changing fuel and oil components.

With the engine and test conditions used for these studies, it is obvious that a nonleaded, nonphosphorus gasoline would be best for controlling preignition rate. The best oil would also contain no phosphorus. It should have some metallic detergent to control spark-plug fouling. However, the amount of ash-forming material required depends on the critical balance between preignition and spark-plug fouling. In addition, the use of a light distillate base stock with a halogen scavenger would be beneficial in reducing preignition rate. It must be remembered, however, that these ideas must be integrated with cleanliness, wear, and rusting studies to finalize a well-balanced oil-fuel combination.

■ **To Order Paper No. 371B . . .** from which material for this article was drawn, see p. 6.

VTOL Progress Demands Special Engine Design

Based on paper by

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ENGINES designed specifically for application to VTOL have so far been lacking. Because of this almost all have had to rely on ill-assorted collections of gear boxes, transmission shafts, clutches, and so on. The result has been costly, unreliable, and uncomfortable vehicles.

When they arrive, power systems for satisfying the lift and thrust requirements of a VTOL aircraft may take one of the following forms:

1. The propulsion engine can be used to provide direct lift.
2. A convertible engine can be employed, consisting of a single gas producer which supplies either a lift or a thrust producer.
3. Separate engines for lift and thrust can be used.

Since the lift needed for vertical take-off is about five times greater than the static propulsive thrust, propulsive engines are not easy to adapt for lift. Even though the specific fuel consumption at high thrust does not have to be low, thrust boosts of the required magnitude are hard to achieve. Also, once the aircraft is airborne and the engine throttled back to a fraction of full power, the sfc must be as low as possible. Piston engines happen to have the right kind of consumption curve, but they are too heavy for most powered lift applications. Conventional gas turbines are lighter, but much less efficient at low power levels.

One way to hold down fuel consumption is to use two turbine engines in parallel, and switch one off for cruise. It is also possible to build a gas turbine engine in which the sfc is independent of power setting, by heating the compressed air with the exhaust. The added weight and complexity, however, offset the attraction of having a constant sfc.

The convertible engine idea does away with the weight and bulk of having two gas producers, as would exist if separate engines were used. In addition, the gas producer operates at a high power setting during both modes of operation, lift or thrust. It is especially attractive today in the absence of specially designed lift engines. Existing propulsion engines can be augmented by lower speed, larger diameter air actuators, to yield high thrust when required, without excessive fuel consumption. The great drawback to the convertible engine is the requirement for heavy and complex transmissions for transferring power smoothly between the lift and thrust producers. This, in effect, cancels the weight savings made in the elimination of the additional gas producer.

Most likely to succeed is the separate engine scheme. Here, lightweight turbojet engines can be utilized for lift, without incurring the weight and drag penalties associated with large diameter fans or lifting propellers. The sfc of the lift engine need not be kept at a minimum. It is far more valuable to design the engine so that it can be started, run up to full thrust, and then shut down again in a very short time. A preliminary design for a small lifting jet engine to produce a thrust around 2000 lb has been estimated to have a bare weight of 150 lb. It is thought that such engines could be built in quantity for less than $5 per lb of thrust, by utilizing a very light simple construction. Present-day jet propulsion engines cost in the range of $15-$20 per lb of thrust.

■ **To Order Paper No. 337B . . .** from which material for this article was drawn, see p. 6.

Carburetor Throttle Body Deposits Cut Fuel Economy

Based on paper by

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CARBURETOR throttle body deposits, if permitted to form to a critical level, cause engine malfunctioning at idling conditions. They also cause poor fuel economy. Yet 75% of the cars inspected in one area a few years ago suffered to some extent from these deposits. Detergent additives in gasolines are being widely used to combat this problem.

These deposits form from a mechanical separation of foreign material from the air which enters the carburetor. The separation occurs when the throttle plate is in idle position.

The critical region of deposit formation, as shown in Fig. 1, is on the throttle body walls, opposite the edge of the throttle plate.

Buildup of the deposit ridge necessitates frequent throttle-plate and idle-mixture screw adjustments . . . and ultimately removal of the carburetor for cleaning is required. This type of deposit is especially critical in multi-barrel carburetors, where the throttle-plate-to-wall clearance is much smaller than in a single-barrel carburetor.

The main contributor to throttle body deposits is blowby gas — with lesser amounts contributed by exhaust gas, dust, and dirt (according to H. W. Sigworth and J. Q. Payne).

Congested traffic areas are particularly instrumental in producing these deposits, since the stop-and-go traffic pattern gives ample opportunity for crankcase fumes as well as exhaust gases from other vehicles to collect under the hood and be drawn into the carburetor.

The gummy constituents found in blowby gases, rather than gasoline gums, serve as a binder to hold the foreign particulate matter together in the throttle body, because at idle position no gasoline passes the edge of the throttle plate.

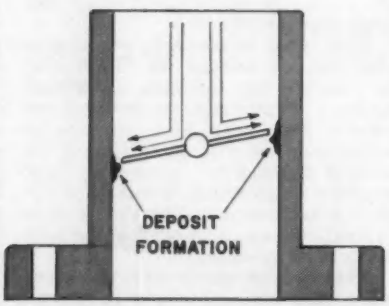

Fig. 1 — Throttle body deposits.

■ **To Order Paper No. 379D . . .** from which material for this article was drawn, see p. 6.

SAE NEWS

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SAE Is Making New Attack On Energy Conversion Problems

Practical, "earthbound" approach characterizes Unconventional Powerplants Subcommittee plans for fresh studies of problem fundamentals.

LED BY University of Wisconsin's Professor Philip S. Myers, SAE is on its way to updating members on the whole energy conversion area — which is so fundamental to future powerplant progress. The Energy Conversion session scheduled for the 1962 SAE Automotive Engineering Congress in Detroit next January is the most immediate indication of SAE progress in this area.

This 1962 SAE Annual Meeting session will attack the problems differently than have any previous SAE presentations. The January session will be "earthbound." It will relate energy conversion fundamentals to problems likely to be faced by a majority of powerplant engineers in the next decade or two. It will evaluate energy converters realistically.

Important in setting the base for the entire session will be a University of Wisconsin evaulation based on studies started early in 1960 — and only now coming to conclusive fruition. This paper will review basic thermodynamic limitations of all types of energy conversion devices . . . and will include also comparisons of such things as efficiency, weight, and bulk. It will be made available before the January presentation to a wide group of engineers and researchers directly concerned with their own energy conversion studies. And time will be allotted at the session itself for these "experts" to debate the Wisconsin conclusions.

Another paper scheduled for this January session is one company's evaluation of the practical and thermodynamic limitations which apply to various fuel cells.

Indications are that an economically attractive fuel cell system will be found to require:

- Ability to utilize hydrocarbon fuel and air;
- Incorporation of fuel catalysts more active than any now known;
- Ability to operate close to atmospheric temperatures and pressures.

The January program will also contain some late reports on Navy studies on thermo electric equipment.

Responsible for this particular session is the recently organized Unconventional Powerplants Subcommittee of the SAE Powerplant Activity Committee — which Professor Myers chairmans. Working with him at this time is R. W. McJones of Cummins Engine Co. Other Subcommittee members are currently being selected.

Workshop to Focus In Experimental, Test Areas

A DAY-LONG "Experimental Engineers' Workshop" at the 1962 SAE Automotive Engineering Congress in Detroit next January will focus attention more sharply on current automotive test, research, and development activity than at any previous time in SAE history. Some discussion of these phases of engineering has been a part of almost every SAE national meeting. But never before have current developments been so fully canvased in selection of material to be presented. Nor have previous discussions had as great a combination of breath and depth.

Nine papers already are scheduled for the workshop, with engineers from Dana, Buick, Chevrolet, Ford, Chrysler, American Motors, and Saginaw Steering Gear named to present the data. Cycle testing, vibration testing, and brake testing are among the topics to be discussed. Material will be presented also on a new averaging engine pressure indicator, a pure sheet test for adhesive bond, photo stress analysis of automotive structures, testing high-pressure, high-temperature power steering hoses, and new tools and techniques for acceleration and fuel measurements.

This unique session will be chairmaned by N. E. Farley. Its secretary will be Victor Hopeman. It was developed by the Testing, Research, and Development Subcommittee of the Passenger Car Activity Committee.

SAE MEETINGS Plans Already Reach to 1965

Stephen J. Tompkins, chairman, EAB National Meetings Planning Committee

BEYOND the year-ahead calendar of SAE national meetings which appears each month in SAE Journal (see p. 117 of this issue), EAB's National Meetings Planning Committee already has somewhat more than tentative plans reaching as far ahead as 1965. A recently-issued set of national meetings schedules, for example, include fixed schedules for 1961 and 1962; "proposed" schedules for 1963, 1964, and 1965.

Such advance planning is desirable for many reasons; necessary if EAB is to insure adequate hotel and meetings accommodations.

The already-fixed 1962 list of SAE national meetings looks very much like the 1961 list — except for one important change:

> **In the Fall of 1962 (October 29 — November 2), there will be held at the Bellevue Stratford Hotel in Philadelphia "COMBINED NATIONAL FUELS & LUBRICANTS, POWERPLANT, AND TRANSPORATION MEETINGS."**

This will be Philadelphia's first SAE national gathering since the Golden Anniversary Fuels & Lubricants Meeting in 1955.

The 1962 list — like that for 1961 — shows meetings to be held in eight cities. In 1963, however, the proposed schedule lists 10 cities; in 1964, eight; and in 1965, nine. (The difference in totals is due chiefly to combinations or lack of combination of certain of the special-interest meetings.)

Summer Meetings

Following a decision which had to be made three years ago to insure hotel accommodations, the SAE Summer Meeting returns to Chalfonte-Haddon Hall in Atlantic City for 1962. Sites for further-in-the-future Summer Meetings are: 1963 — Queen Elizabeth Hotel MONTREAL; 1964 — Edgewater Beach Hotel, CHICAGO; 1965 — Sheraton Park Hotel, WASHINGTON, D.C.

PAC . . .

. . . Tire Subcommittee considers tire book potentials.

THE TIRE SUBCOMMITTEE of SAE's Passenger Car Activity Committee is giving serious consideration to developing and requesting publication of a special SAE publication on tires, according to Subcommittee Chairman R. J. Piersol.

The 2-ply tires which will be original equipment on many 1962 models provide just one of the tire areas in which the committee sees opportunity for fruitful current exchange of technical data among automotive engineers. (A session is scheduled at the 1962 SAE Automotive Engineering Congress in Detroit next January to explore the relative performance of 2-ply and 4-ply tires.)

Of current Subcommittee interest also are new studies by non-commercial as well as by commercial researchers of frictional behavior of the rolling, slipping, and sliding tire. Basic research results from important tire companies are also being examined as possible chapters in the proposed book and/or as papers at future SAE national meeting sessions.

New Meetings "Guideposts" Detail Chairman Functions

THE GENERAL CHAIRMAN of an SAE national meeting has seven specific functions in addition to being liaison between the SAE Engineering Activity Board and his General Committee, the Host Section, and the SAE Staff. These seven functions, as detailed in EAB's recently issued "Guideposts for Organizing SAE National Meetings," are:

- Coordinates technical program with other meeting events.
- Responsible for securing speaker and toastmaster for luncheon programs.
- Decides on holding of special events, such as inspection trips; and arranges them if they are held.
- Appoints an SAE member to handle local publicity in connection with the meeting.
- Coordinates Host Section participation with that of other groups.
- Delegates certain specific responsibilities to Host Section (such as attendance promotion, reception committee, membership promotion, ticket sales for dinners, luncheon, or special events, etc.)
- Personally welcomes members and guests at first session or during dinner or luncheon.

These "Guideposts" first were distributed to General Chairmen and others directly concerned with handling of national meetings, but copies are available without charge to any interested SAE member . . . on request to EAB Secretary, W. I. Marble at SAE Headquarters in New York. The "Guideposts" include also a detailing of Host Section and SAE Staff responsibilities in connection with national meetings . . . and notes that the EAB "is responsible for all national meetings of the Society" and that the General Chairman of each meeting is appointed by EAB.

Commenting on SAE's Pan American Day technical program, Alaric Paris, assistant director, Mercedes-Benz of Brasil, outlined the extreme problems of quality control facing the 11 automotive manufacturers in Brazil. Mr. Paris stopped in at SAE Headquarters during his recent business trip to the U. S. He is the chairman of the Technical Committee of the Brazilian automotive trade association, Sindicato da Industria de Caminhoes Tratores Caminhoes E Veicalos Similares.

SAE Material Specs Help NATO Subagency

SAE AERONAUTIC MATERIAL SPECIFICATIONS and other SAE materials specifications are among those assembled for use by NATO countries, SAE Journal learned recently. Many SAE specs are included in the "Materials Properties Handbook" which is developed and published for NATO's Advisory Group for Aero Research and Development by the Royal Aeronautical Society of Great Britain.

In performing this function for AGARD, the RAS picks up and correlates aeronautic materials specifications from all countries and companies in the NATO organization.

Distribution center for this NATO-AGARD Materials Properties Handbook in the United States is the National Aeronautic and Space Administration office in Washington, D.C. Handbooks have already been completed on aluminum and steel. Another, soon to be finished, includes titanium, magnesium, and nickel alloys.

Wright Brothers Medal to Greatrex

F. B. Greatrex

FERDINAND BASIL GREATREX has been awarded SAE's 1960 Wright Brothers Medal for his paper, "By-Pass Engine Noise," presented at the SAE National Aeronautic Meeting in New York in April, 1960.

In this paper, Greatrex concludes in part that "the jet noise of the by-pass engine, of by-pass ratio around 1, designed for efficient mixing of by-pass gas and hot gas streams before being discharged to atmosphere, will be some 4 db quieter than if the two streams are discharged separately."

Greatrex is assistant chief engineer of Rolls Royce, Ltd., and started his work on jet noise problems in 1951 and early 1952. Since that time he has made important contributions to the technical literature on this subject, including papers read before the Royal Aeronautical Society, the 1955 Anglo-American Conference in Los Angeles, the American Society of Mechanical Engineers and others.

In 1957, Greatrex was awarded the Royal Aeronautical Society's Bronze medal for "work on the reduction of noise from aero engines."

He is a graduate of Haileybury College and Cambridge University (Caius College), and spent three months at Heidelberg University, learning German.

Greatrex joined Rolls Royce in 1938 as aerodynamicist at Hucknall Airdrome. He became manager at Hucknall in 1956, and thus directly concerned with flight testing. He came to his present position as assistant chief engineer (staff engineering) at Derby in 1961.

FORD LEVACAR operation is explained by SAE President A. A. Kucher (left) to Fred Fulton (center) and C. A. Dillinger. Fulton is chairman of SAE Oregon Section. Dillinger was general chairman of SAE National West Coast Meeting.

Engineers predict 750 hp trucks by 1975

at SAE National West Coast Meeting

HIGHER HORSEPOWER is on the way for truck engines according to engineers at SAE's National West Coast Meeting. This trend portends a powerful effect on all of tomorrow's truck design. Specific forecasts include:

1. Horsepower of 750 or more for sure by 1975.

2. Equipment up to 108-in. wide.

3. Trailers 27 ft long in trains of three and 40 ft trailers in combinations of two commonly used.

4. Speeds of 65 mph common by 1975.

5. Diesel remaining most practical truck engine for many years to come.

The desire for increased speeds has been leading to higher and higher horsepower. In 1940, trucks ran 470 ton-miles per person. By 1960, the figure reached 1553 ton-miles per person. In 1980, the run is expected to be 2826 ton-miles per person — which means more speed — and still higher horsepower.

Some engineers, however, oppose this trend to higher horsepower on the basis that better brakes and retarders as well as increased maintenance will be needed. This, they fear, will lead to increased operating costs.

As a compromise, one engineer suggested the use of an auxiliary engine which cuts in and out as more or less power is needed.

Brake experts feel they can come up with the brakes needed to meet higher horsepower requirements. They cite an improved plumbing system as one way to improve braking power. A 98-ft, 130,880 lb truck-trailer combination traveling at 40 mph took 158½ ft to come to a halt in a panic stop. After replumbing (changing valves, elbows, hose, and tubing), this vehicle was able to stop in 124 ft when operating under the same conditions.

With the advent of three, four, and five-trailer combinations, electro-magnetic braking systems probably will come into being. After all, air will only move so fast. Three-trailer trains, 125 ft long and weighing 160,000 lb, with speeds up to 100 mph already are being predicted.

Axle designers have a reserve of gear box housing designs which they feel can easily keep pace with any further moves to higher horsepower. Many engineers, however, voiced the need for a common axle-transmission lubricant.

A new retarder design turns a diesel engine into a compressor which will absorb approximately 70% of the horsepower. With this retarder, the engine temperature will not vary uphill or down, as the radiator is absorbing the downhill energy. Brakes are said to last two-to-five times as long because long-drag applications are eliminated.

Meeting Events

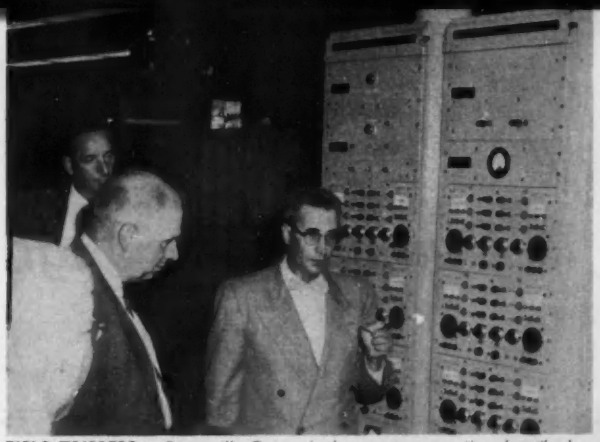
A luncheon, dinner-dance, and two tours were held in conjunction with the SAE National West Coast Meeting.

Guest speaker at the luncheon was Dr. J. Whitcomb Brougher, noted lecturer and humorist.

SAE President A. A. Kucher presented an inspirational talk "Reflections and Projections" at the dinner-dance. Toastmaster at this function was Z. C. R. Hansen, president, Diamond-T Motor Truck Co. Kucher brought along a display model of Ford's Levacar which aroused much interest among the dinner-dance participants.

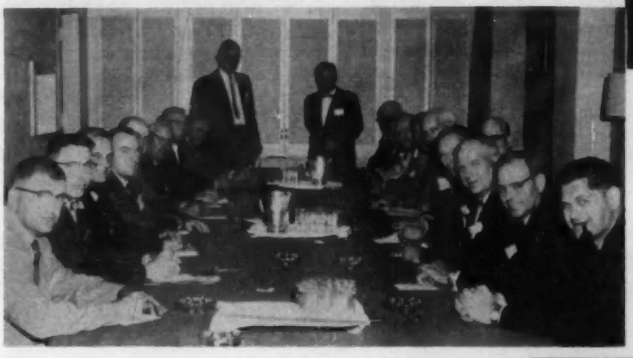
Tours to the Bonneville Power Administration Dispatching Center and along the Columbia River including Mt. Hood were well attended by SAE'rs. The Bonneville Center, one of the largest of its kind in the world, is responsible for transmission and distribution of power produced at 13 Federal dams in the Northwest area. Members witnessed the Northwest Power Pool Interchange Master Control System in operation.

The Columbia River — Mt. Hood Tour was a scenic trip along the famous Columbia River, past innumerable waterfalls, including the beautiful Multnomah Falls — Bonneville Dam and Powerhouse fish ladder, where fish not only climb over the dam to higher water, but are counted and classified — and through the beautiful Hood River Valley to Government Camp on the south side of Mt. Hood where a real western "cook-out" buffet luncheon was waiting.



FIELD TRIPPERS to Bonneville Center had computer operation described to them.

SAE PRESIDENT A. A. Kucher (right) presents plaque for outstanding service to C. A. Dillinger. Dillinger was head man in setting up SAE National West Coast Meeting.



SECTIONS' OFFICERS luncheon meeting was held during SAE National West Coast Meeting.

GUEST SPEAKER at Meeting Luncheon was Dr. J. Whitcomb Brougher, noted lecturer and humorist. Mel Gordon, past chairman of SAE Oregon Section and SAE President A. A. Kucher are seated to the right of the speaker.

Committee chairmen for the SAE National West Coast Meeting were: **C. A. Dillinger,** general chairman; **F. D. Fulton,** program chairman; **E. E. Werlein,** arrangements; **E. M. Kruger,** house; **P. T. King,** registration and reception; **R. B. Gaulke,** banquet; **A. W. Andersen,** finance; **T. C. Ammons,** publicity; **H. C. Jacobsen,** field editor; **J. S. Poulson,** transportation, and **Mrs. C. A. Dillinger,** ladies activities.

West Coast Meeting was sponsored by the SAE Fuels and Lubricants, Powerplant, Transportation and Maintenance, and Truck and Bus Activities, with the cooperation of the SAE British Columbia, Northern California, Northwest, Oregon, San Diego, Southern California, and Spokane-Intermountain Sections, and the Salt Lake City Group.

Sidelights at the National West Coast Meeting

ART DILLINGER's right hand was bitten by a large Oregon chipmunk, so that a tetanus shot was necessary. It happened in Lloyd Park adjacent to the Sheraton-Portland Hotel. Talk about the Wild West!

BILL NOSTRAND (Winslow Engineering) has perfected a new way to get attention at a technical session ——— merely shove the podium, water pitcher, and glass on the floor. It's guaranteed to get results.

ATTENDING THE DINNER-DANCE were: (left-to-right) Z. C. R. Hansen, W. G. Nostrand, Gilbert Way, and C. A. Dillinger. Hansen was toastmaster at the Dinner-Dance. Nostrand presented a technical paper at the Meeting. Way was chairman of one of the technical sessions. Dillinger was general chairman of the Meeting.

ROBERT SWAN, Resistoflex sales engineer from Anaheim, California, takes a deep statistical interest in the operational results of his 1958 Mercedes-Benz 180D diesel passenger car. He shared his interest and these results with fellow SAE members, when he was coffee speaker at a **NORTHERN CALIFORNIA SECTION** meeting recently.

The 177-in. long car has a 107.8 cu in. displacement engine, which produce 1 hp per 57.5 lb of curb weight — which makes it underpowered by American standards, but it is long on economy, as some of the following figures show.

In 38 months Swan drove the car 100,000 miles. (Based on measurements taken regularly with a micrometer, he estimates he'll have to have the rear brakes relined at 105,000 miles, the front brakes at about 125,000 miles. So far, he's just had them cleaned and adjusted every 20,000 miles — but they do tend to chatter.)

Among the 100,000-mile operating statistics he revealed in his talk were the following:

Fuel cost per month was $22.73 for 2631 miles of driving per month. He got 32.4 mpg. His total operating costs for the 100,000 miles — including some $370 for various state and federal taxes — were $1466 . . . or 1.5¢ per mile. In addition, he spent $177 for "preventive maintenance replacements" (like motor mounts, generator brushes, fan and generator belts, and gaskets), but his actual repair bill totaled only $75. (The two biggest items were $20.20, including labor, for an R&R crankshaft pulley and $15, including labor, for an R&R thermostat. . . . The thermostat was replaced at 62,000 miles.)

All of which, Swan adds up to $1750 (including 2% allowance for miscellaneous costs) . . . or 1.8¢ per mile for his first 100,000 of operation. For 11 years, he told his audience, he has used the same kind of book for recording purchases and expenditures when they are made, and he feels his records are accurate to within 1–2%. (He kept similar records on his 1956 Chevrolet.)

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NORTHERN CALIFORNIA SECTION is gathering some not-usually-available information about its individual members. The Section's hope: To serve individual SAE members better by providing interesting programs of more value to individuals in their own jobs and professions.

Nine of the 30 "questions" are aimed at getting an attendance pattern from the individual, by asking him to check which of last year's Section meetings he attended. (The meetings, speakers, and topics are listed.)

If the returns are numerous, as Section officers hope, Northern California will be able to study member needs in terms of age groups, Section activity-or-non-activity groups, industrial interests . . . and will have also a reasonably good picture of why people stay away from meetings as well as why they come.

Rambling through

RAMBLING THROUGH GOVERNING BOARD MINUTES reveals that: : :

Publicity chairman Dick Thorman of the **SOUTHERN CALIFORNIA SECTION** plans to send biography news stories about each of the Section's Governing Board members to local area newspapers. . . . **MID-CONTINENT SECTION** this year is asking its Activity Vice-Chairmen (each of whom is responsible for a meeting during the year) to get firm commitments from invited speakers 90 days before the meeting date. . . . **TEXAS SECTION** expects to have at least two meetings in Fort Worth during the 1961–62 Section year — and one in the Oak Cliff area of Dallas. The other meetings will be held in convenient places depending on the meeting subject. . . . A special invitation will go to all plant managers and company presidents in the **WESTERN MICHIGAN SECTION** to attend the Section's October meeting — which is being planned as SAE President's night. . . .

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SAE STUDENT ENROLLMENT is greater in **Detroit Section** colleges this year than in the colleges in any other Section territory. Last year totals were greater in **Southern California Section** institutions. Of the 3,645 SAE Enrolled Students in 118 SAE-approved colleges and universities, 465 were in the seven institutions located in Detroit Section area; 377 in those in Southern California Section area.

While SAE Student Enrollment is less for the October-July 1960–61 period than for the previous 12 mo — as was student enrollment in most engineering societies — SAE gains have been recorded in about 35% of the individual schools. In the 16 colleges outside of any Section territory, gains in SAE Student Enrollment have been recorded in 10 (62%).

Section territories in which the SAE Enrolled Student totals have gone up this year are: **Milwaukee; St. Louis; Metropolitan; Pittsburgh; Texas; British Columbia; Cincinnati; Williamsport; Atlanta; Oregon; Southern New England; Syracuse; New England; Twin City; Alberta; and Washington.**

Definite gains in SAE Student Enrollment have been made in 42 individual colleges and universities. Among the institutions where the number of SAE Enrolled Students is greater in 1961 than in 1960 are: University of Detroit; University of Toledo; California State Polytechnic College (Kellogg-Voorhis Campus); Marquette University; University of Wisconsin; Parks College of Aeronautical Technology; Academy of Aeronautics; The City College (NY); Manhattan College; Brooklyn Polytechnic Institute; Fenn College; Royal Military College (Ontario); Seattle University; San Jose State College; Villanova University; Arlington State College (Texas); University of British Columbia; University of Cincinnati; University of Kentucky; Pennsylvania State University; Georgia Institute of Technology; Oregon State University of Massachusetts; Hillyer College, University of Hartford; Cornell University; Worcester Polytechnic Institute; Massachusetts Institute of Technology; South Dakota State College; University of Alberta; University of Rochester; George Washington University; University of Saskatchewan; Michigan College of M&T; University of Manitoba; Clemson College; University of Arizona; University of Florida; Tulane University; College of Engineering (Guindy, India); University of New Mexico; North Carolina State College. (Included in these "gains" are a few institutions where SAE Enrolled Students appear in 1961 for the first time.)

the Sections

A DIAGRAM OF FLIGHT PATTERNS serving the Hawaiian Islands was one of the facilities Hawaiian Section members saw in action when they visited the Federal Aviation Agency's new $4,000,000 Honolulu Route Traffic Control Center and International Flight Service Station late in July.

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HAWAII SECTION's automotive engineers were briefed in related engineering technologies when they visited the Honolulu Air Route Traffic Control Center and International Flight Service Station late in July.

Located at Diamond Head Crater, the new Federal Aviation Agency-controlled Center and Flight Service Station is fireproof, blast-resistant, and completely air-conditioned. A standby power system, capable of carrying the electronic load of the entire building is located in a separate structure in the rear. More than $4,000,000 are invested in the facility, which requires 34 skilled technicians for day-to-day maintenance. Some 160 air traffic control specialists staff the facility 24 hr per day, 365 days each year . . . to carry out the prime objective of the facility: air traffic control.

The Honolulu Flight Information Region served by the facility covers about 5,300,000 sq mi. In addition the Center has a network of more than 2,500 miles of airways linking the Hawaiian Island Chain. The Honolulu IFSS is the communications center of the Pacific. Its Plan 59-A switching system — first to be installed in the nation — gives direct contact with stations halfway round the world.

From FAA Watch Supervisor A. Burton, the 35 Hawaiian Section members heard a description of the technical phases of the facility's operation while they actually watched the operations taking place. From Burton they learned also that the FAA employs four kinds of engineers: electronic, civil and structural, electrical, and mechanical.

The mechanical engineers, Burton said, design and specify the types of gasoline and diesel powerplants to be used for standby generation, and deal with problems of heating, ventilating, and air conditioning. Also, they develop or modify special equipment used in air traffic control. The mechanical engineers, he said, are faced with many challenging problems in performance analysis of powerplants and attendant controls, such as fire detection, fuel supply and fuel metering or purging systems.

SAE LETTERS FROM READERS

From:
Edward Adams Richardson
31 East Church St.
Bethlehem, Pa.

Dear Editor:

Dr. P. H. Schweitzer's letter (p. 110, May, 1961) discussing the 1961 SAE Annual Meeting paper by Dr. J. S. Meurer deserves comment. It might interest *SAE Journal* readers to know that, back in 1922, several papers on detonation, including one by the late Dr. Thomas Midgley, Jr., were in serious conflict.

About that time I set up a theory of gaseous combustion that seemed plausible, then proceeded to show that every observation of each of the three or four papers could be fully accommodated. The resulting 70-page, double-spaced, typed paper was offered to the SAE about 1924, but it was not published.

I proceeded to set up the criteria for engine operation without detonation and developed a process for fuel preparation that was the basis for U.S. Patent No. 1,876,168, "Method of Preparing Fuels," issued in 1932.

In June 1932 I presented a paper, "Heating Fuels for Injection Engines," at the Oil Power Conference, held at Penn State (Pennsylvania State College, School of Engineering Bulletin, No. 16, April 1933). The paper gave a brief outline of the theory of combustion, then laid down the requirements for combustion without detonation. I said, "If we prevent mixtures of explosive character from developing before ignition, we can prevent the rise of detonation waves."

The patented method was also described. The fuel was placed under pressure in excess of the critical pressure of its vapor, then heated to a temperature in excess of the critical temperature thereof or, if it should be higher, above the self-ignition temperature thereof, then injected and burned. Such a fuel is a "permanent" gas. It is preatomized to molecules, is hot enough to ignite as fast as it mixes with air, has enough energy to promote vigorous mixing of fuel and air, hence, it can be used in rich or lean mixtures. Also, it can produce smoke with the greatest difficulty, since little droplet formation can occur and that only to aggregates of a hundred molecules or less — particles too small

continued on next page

LETTERS

. . . continued

to be visible as "smoke." With such a process, an engine can be built to use any fuel, irrespective of the octane or cetane rating thereof, without detonation.

It was further shown that the fuel could be heated at the required temperatures without cracking. The importance of the methods for military purposes were noted.

I had noted the possibility of injecting the fuel near a spark plug, but considered the method unpromising. Such a method, favored by Texas Co., is alleged to have been developed after some twenty years of study. One of the research workers was present at Penn State the year following the Conference, so he must have known about my paper.

The National Advisory Committee for Aeronautics tried heating fuels before injection. In Technical Note, No. 565, 1936, "Influence of Fuel-Oil Temperature on Combustion in a Prechamber Compression-Ignition Engine" (which was based on my paper of 1932), the fuel process of that paper was approximated as the temperature of the fuel was raised. Only 4% excess air was used. At times the exhaust was clear. Detonation was reduced. The polish of the cylinder head of the engine was barely fogged by the products of combustion, instead of being carbonized. The thermal efficiency was increased by enough to cover the heat added in the fuel. Unfortunately, the NACA engineers tried to inject and *control* the hot fuel, using a coil heater scarcely adapted to the temperatures and pressures employed, so they had a very complicated and unsatisfactory fuel system. The heater exploded after some fifty hours.

About 1940 a Seminar or Conference was held at Penn State, at which I presented another paper, which showed how the fuel system might be controlled and operated in a relatively simple and satisfactory manner.

During World War II the need for better engines forced a program of high-octane gasoline plant building — but such a program was working in the wrong direction. Instead of being able to use any fuel, the Services went to the most costly single fuel.

My papers may prove helpful to Dr. Schweitzer in understanding the problems he discussed in his letter, particularly if he investigated the temperature of the surface over which the fuel was spraying to learn why carbonization did not occur.

This letter is written because there is so much in the past that could be useful in many places in the present — and it seems well to note specific examples.

SAE Section

ALBERTA

October 16 . . . William McDowell Smyrl, sales promotion. J. I. Case, Co. "Terranamatic Transmission." Meeting place: Calgary Shopping Center, Park Lane, Calgary, Alberta, Can. Dinner 7:00; meeting 8:00 p.m.

ATLANTA

October 2 . . . Field Trip — Tour of new air terminal and airport facilities. Including Delta Air Lines, Eastern Air Lines, and FAA communications center. Meeting place: Georgian Room, Atlanta Municipal Air Terminal, Hapeville, Ga. Social Hour 6:30; dinner 7:00; meeting 8:00 p.m.

BALTIMORE

October 19 . . . John Roper, John Roper Co. "Roper Rat Trap" — System of eliminating atmospheric discharge of oil vapors. Meeting place: Engineers Club, 7 West Mt. Vernon Place, Baltimore, Md. Dinner 7:00; meeting 8:00 p.m.

BUFFALO

October 3 . . . Plant Tour — Bethlehem Steel Corp., Lackawanna, N. Y. Dinner 7:00; meeting 8:00 p.m.

CENTRAL ILLINOIS

October 23 . . . "Fuel Cells." Speaker from Allis-Chalmers Mfg. Co. Meeting place: Elks Club, Springfield. Dinner 6:30; meeting 8:00 p.m.

FT. WAYNE SECTION

October 11 . . . E. A. Ball, gear analysis engineer, National Broach & Machinery Co. "Quality Gear Control." Meeting place: Hobby Ranch House, 3204 N. Anthony Blvd., Ft. Wayne, Ind. Dinner 6:30; meeting 8:00 p.m.

INDIANA

October 19 . . . Brig.-Gen. Paul T. Preuss, military advisor, Federal Aviation Agency, USAF, Washington, D. C. "Supersonic Transport." Meeting place: Continental Hotel, 410 N. Meridian, Indianapolis, Ind. Dinner 7:00; meeting 8:00 p.m.

METROPOLITAN

October 5 . . . M. A. Remondino, research representative, Detroit Laboratories, Ethyl Corp., Ferndale, Detroit. "Diagnosing Some Fuel System Ailments — Causes and Cures." Meeting place: Brass Rail Restaurant, Fifth Ave., between 43rd & 44th Sts., Manhattan. Social hour 5:30; dinner 6:30; meeting 7:45 p.m.

October 12 . . . J. R. Hull, assistant chief engineer, Bearings Division, Torrington Co., Torrington, Conn. "Need Help Choosing Bearings?" Meeting place: Roger Smith Hotel, Lexington Ave. & 47th St., Manhattan. Luncheon 12:00 noon.

October 18 . . . C. R. Englebry, director of engineering, Lockheed Aircraft International, Inc., Los Angeles. "The Nihon-Lockheed Monorail." Meeting place: Henry Hudson Hotel, 57th St. & Ninth Ave., Manhattan. Meeting 7:45 p.m.

November 2 . . . Representatives from Mack Trucks, Inc.; International Harvester Co.; and White Motor Co. "Guaranteed Maintenance." Brass Rail Restaurant, Fifth Ave., between 43rd & 44th Sts., Manhattan. Social hour 5:30; dinner 6:30; meeting 7:45 p.m.

November 9 . . . Representative from Republic Aviation Corp., Farmingdale, N. Y. "Plasma Engines." Meeting place: Republic Aviation Corp., Farmingdale, N. Y. Sponsored cocktail hour; dinner 6:30; meeting 7:45 p.m.

MID-MICHIGAN

October 23 . . . Joseph Bidwell, general manager, research. "Electronic Highways." Meeting place: Oldsmobile Auditorium, Lansing, Mich. Coffee Speaker: Lt. Lester Coykendahl, Mich. State Police. Dinner 6:30; meeting 8:00 p.m.

MONTREAL

October 23 . . . Sheraton Mount Royal Hotel, Burnside & Peel, Montreal, Canada. Dinner 7:00; meeting 8:00 p.m.

Meetings

PHILADELPHIA

October 11 . . . Engineers Club, 1317 Spruce St., Philadelphia, Pa. Dinner 6:30; meeting 8:00 p.m.

PITTSBURGH

October 24 . . . Robert C. Downie, chairman and executive director, Port Authority of Allegheny County. "Mass Transportation for Allegheny County." Meeting place for dinner; Webster Hall Hotel, 6:30; meeting: Mellon Institute, Pittsburgh, Pa., 8:00 p.m.

ROCKFORD-BELOIT

October 2 . . . Robert G. Pruett, senior operations analyst, McDonnell Aircraft Corp. "Effects of Nuclear Weapons on Aircraft." Meeting place: Wagon Wheel, Rockton, Ill. Social hour 6:00; dinner 6:45; meeting 8:00 p.m.

SOUTH TEXAS GROUP

October 23 . . . Dr. Norman H. Abramson, director of Department of Applied Sciences, Southwest Research. "Hydrofoils." Meeting place: Petroleum Center Club, 900 N.E. Military Dr., San Antonio, Texas. Dinner 7:00; meeting 8:00 p.m.

TEXAS GULF COAST

October 16 . . . Chester C. Sconyers, Perry Filter Sales Co. "Conditioning of Cooling Systems." Meeting place: Houston-Engineering & Scientific Society, 2615 Fannis St., Houston, Texas. Social gathering 6:00; dinner 6:30; meeting 7:45 p.m.

TWIN CITY

October 18 . . . SAE President Andrew A. Kucher, Ford Motor Co. Present status—future development—"Ground Effect Vehicles." Meeting place: Hasty Tasty Restaurant, Lake St. & Hennepin Ave., Minneapolis. Dinner 7:00; meeting 8:00 p.m.

WICHITA

October 19 . . . Vern Lewis (moderator). Panel discussion: "Recent Advances in Lubricants." Special feature—field trip: Skelly Oil Co. Meeting place: Skelly Oil Co., El Dorado, Kan. Dinner 6:30; meeting 8:00 p.m.

SAE National Meetings

1961

October 9–13
Aeronautic and Space Engineering and Manufacturing
(including engineering display)
The Ambassador, Los Angeles, Calf.

November 8–10
Fuels and Lubricants
Shamrock Hotel, Houston, Texas

1962

January 8–12
Automotive Engineering Congress and Exposition
Cobo Hall, Detroit, Mich.

March 12–16
Automobile Week
(combined National Automobile and Production Meetings)
Sheraton-Cadillac, Detroit, Mich.

April 3–6
Aeronautic
(including production forum)
Hotel Commodore, New York, N. Y.

June 11–15
Summer
Chalfonte-Haddon Hall, Atlantic City, N. J.

August 13–16
National West Coast
Biltmore Hotel, Los Angeles, Calif.

September 10–13
Farm, Construction, and Industrial Machinery
(including production forum and engineering display)
Milwaukee Auditorium, Milwaukee, Wis.

October 8–12
Aeronautic and Space Engineering and Manufacturing
(including manufacturing forum and engineering display)
The Ambassador, Los Angeles, Calif.

October 29–November 2
Combined National Fuels and Lubricants; Powerplant and Transportation Meetings
Bellevue Stratford, Philadelphia, Pa.

SAE MEMBERS

ROYAL WELLER, former vice-president of engineering of the Stromberg-Carlson Division, has been appointed to the newly-created position of director of engineering in the Space Systems Division of the Lockheed Missiles & Space Co., a division of Lockheed Aircraft Corp. He is responsible for all design and analytical engineering.

WILLIAM F. BALLHAUS has been named executive vice-president of Northrop Corp. He has been a vice-president of Northrop and general manager of its Nortronics Division since 1957 and is also a member of the board of directors of Page Communications Engineers, Inc., a Northrop subsidiary.

MAYNARD J. ISLEY has been appointed as the first of a group of specialized engineers who will be in charge of Studebaker-Packard's new research division.

Isley is a research engineer in Chrysler Corp's ballistic weapon systems.

G. DOUGLAS SIMONDS, formerly engineering vice-president, has been named vice-president and technical consultant of FWD Corp., Clintonville, Wis. Replacing Simonds as engineering vice-president is **ARMAND W. WOTHE.** Prior to joining FWD, Wothe was vice president-sales and engineering of the Hendrickson Tandem Corp., Butler, Ind., a division of Hendrickson Mfg. Co., Lyons, Ill., where he was sales engineer.

LEO A. CARTER, former vice president-general manager of the Santa Monica Division of Douglas Aircraft Co., is now with the Lockheed Missiles & Space Co. a division of Lockheed Aircraft Corp. as assistant for management evaluation to the vice-president and Space Systems Division general manager. Carter will be responsible for management analysis of Space Systems Division operations, to improve methods of conducting research and development activity.

CORWIN D. MC LEAN is now supervising research engineer — petroleum products research department, California Research Corp. He will be located at Louisville, Kentucky, as Cal-research representative.

RICHARD C. ST. JOHN is now associated with The Martin Co. In his position as senior engineer he determines and directs the use of explosive devices and components in missiles.

St. John was formerly project engineer with Magnavox Co.

MAX K. BRAND has been appointed regional service director, European and Near Eastern Area, American Motors Corp. He was formerly Pacific Area field engineer for Ford International Division, Ford Motor Co.

Dybvig

Schomburg

Henson

Dana appoints . . .

C. C. DYBVIG has been appointed to the newly created position of vice-president of marketing for the Dana Corp. In this position Dybvig will coordinate sales for Dana's Detroit, Con-Vel and Transmission and Gear Divisions as well as continuing with his present sales responsibilities. He joined the Dana Corp. in 1954 as general sales manager and in 1958 was elected Vice-President — Sales.

Dybvig served on the Detroit Section Governing Board for seven years prior to his term as chairman of the Section 1956–57. He is currently chairman of the committee planning the banquet at the 1962 Congress and Exposition of Automotive Engineering.

Additional appointments at Dana include those of **W. H. SCHOMBURG, JR.** and **JOHN P. HENSON.** Schomburg, assistant general sales manager since 1959, has been named general sales manager and Henson has assumed the position of assistant general sales manager. He was previously sales manager of Dana's Universal Joint Division.

PAUL F. ALLMENDINGER has been appointed director of engineering for the Electric Autolite Co.'s electrical products group. In addition to managing engineering activities for generators, alternators, controls, starting motors, ignition and other automotive electrical parts, Allmendinger will coordinate and initiate product development.

He was previously director of engineering, Alemite and Instrument Division, Stewart-Warner Corp.

Allmendinger is SAE director 1961–3 and chairman of the SAE Sections Board.

SAE PAST-PRESIDENT ARCH T. COLWELL in recognition of his extensive business and scientific contributions to aeronautics over the years, has been elected a Fellow of The Royal Aeronautical Society of England. Widely known in both aircraft and automotive circles here and abroad, he recently retired as vice president — engineering, research and development of Thompson Ramo Wooldridge Inc. He continues to serve TRW as a member of the board of directors and consultant.

M. CARL HADDON and **WILFRID A. PULVER**, corporate vice-presidents of Lockheed Aircraft Corp., have assumed presidential positions with the renaming of Lockheed's California and Georgia Divisions. Haddon was named president of Lockheed-California Co., the former California Division; and Pulver, president of Lockheed-Georgia Co., the former Georgia Division.

E. S. RUSSEY has been elected chairman of Borg-Warner, Ltd., Letchworth, England. His new duties will be in addition to those he already performs. Besides being a director and vice-president of Borg-Warner, Russey is president and general manager of both the Warner Gear Division at Muncie, Ind., and Warner Gear Co. Ltd. at Windsor, Ontario, Canada.

ROBERT K. NELSON, formerly assistant chief engineer of the Axle Division of Eaton Manufacturing Co., Cleveland has been appointed technical director of Eaton Axles Ltd., Warrington, England.

Nelson and **E. M. DE WINDT**, president of Eaton International and vice-president of Eaton Manufacturing Co. have both joined the Board of Directors of Eaton Axles Ltd.

Townsend Heads Chrysler . . .

Townsend

Colbert

LYNN A. TOWNSEND has been named president of Chrysler Corp. succeeding **L. L. COLBERT**, who has resigned as chairman and president, and also as a member of the Chrysler Board of Directors. Colbert has been elected chairman of the Board of Chrysler Corp. of Canada.

Townsend was administrative vice-president of Chrysler Corp. at the time of his elevation to the presidency. Prior to joining Chrysler Corp. as comptroller in 1957, Townsend was a partner in the accounting firm now named Touche, Ross, Bailey & Smart.

ERWIN E. BIRCHER has been made test engineer in Consolidated Diesel Electric Corporation's power equipment division. He was formerly a field service representative in the firm's aircraft equipment division.

PRIMO L. PINOTTI has been named Chicago district manager, petroleum chemicals, for the Oronite Division of California Chemical Co., a subsidiary of Standard Oil Co. of Calif. Prior to his new appointment, Pinotti was product specialist, petroleum chemicals, in Oronite's home office.

H. GRADY MARSHALL formerly a department engineer, equipment and standards, with Lockheed Aircraft Corp., has returned to the Georgia division as staff assistant to technical service engineer after six months on special assignment in the Sunnyvale, California, Missiles & Space Division of Lockheed.

CLOYD DICKERSON, supervisor, engineering design, Ford Tractor & Implement Division, Ford Motor Co., has retired after 52 years in the automotive industry. His first experience was with the 1909 Reo, then followed association with Hupmobile, Packard and the Curtis A & M Co.

RENE J. BENDER, an editor of "Petroleum Week," a former McGraw-Hill publication, has entered the business of consultant engineering, specializing in matters of petroleum and petrochemicals, their manufacture and their applications.

Bender, a graduate engineer of the University of Paris (France), was, for many years, an engineer and an executive of the Sinclair Oil Corp. in the U. S. and abroad. He is currently engaged by the Ethyl Corp.

EUGENE L. MENCH, staff engineer of the Diamond T Motor Truck Co., has been transferred to the Lansing Division of the White Motor Co. at Lansing, Michigan. The Lansing Division manufactures Reo, Diamond T and several models of White trucks.

Allmendinger

Colwell

Pulver

Haddon

Russey

Nelson

Ainsley Retires . . .

Ainsley

Hamilton

WALTER G. AINSLEY, automotive research coordinator for Sinclair Research, Inc., has retired after 35 years with the corporation. He will be succeeded by **M. L. HAMILTON.**

Ainsley, a pioneer in gasoline knock testing, has been working closely with automotive engineers on problems relating to fuels and lubricants as they apply to innovation in automotive engine design. Three years ago, he set up a Sinclair liaison office in Detroit, and since then he has divided his time between the Detroit office and Sinclair's laboratories in Harvey, Ill. During World War II, he served as consultant on fuels and lubricants to the Office of the Chief of Ordnance.

Hamilton has served variously as Ainsley's assistant director of engine laboratories, for three years as assistant director of the Products Division, and previously as head of the aircraft engine laboratories.

Both Hamilton and Ainsley have been active in SAE. Ainsley has served as vice-president and chairman of various technical committees and Hamilton was 1958-59 chairman of the Chicago Section.

WADE E. CANFIELD has been elected to the board of directors of the S. K. Wellman Co. He is currently vice president in charge of sales at the S. K. Wellman Co. and president and a director of Friction Materials Standards Institute.

RUSSELL A. GRAHAM, vice president of engineering, a director of Maremont Corp., Chicago and a vice president and director of its subsidiary, Saco-Lowell Shops, has been appointed executive vice president and general manager of the textile machinery division of Saco-Lowell Shops.

Graham who has had wide experience in the development and design of special manufacturing equipment and tools, asserted that special emphasis would be placed on forward planning, sales, research, development and engineering in an effort to translate textile mill requirements into machinery suitable for those needs.

DAVID R. KNOX has been appointed director of facilities engineering, Bundy Tubing Co., Detroit. The facilities engineering group is responsible for maintenance of engineering and fabrication standards as well as product quality control.

Knox was manager of the Nine Mile Road plant, Warren, Michigan before this appointment.

E. S. HOWARTH, chief engineer of Alcoa Research Laboratories, New Kensington, Pa., has been appointed assistant chief construction engineer for Aluminum Co. of America with headquarters in Pittsburgh. In addition he will continue as project manager for the planned Alcoa Technical Center at Merwin, Pa.

ROLAND J. FERNEKES has been named director of engineering at Casco Products Corp., a subsidiary of Standard Kollsman Industries Inc. Formerly assistant to the vice-president-operations, he will now be in charge of both product and manufacturing engineering.

A. D. BULLOCK has been named service manager for Kenworth Motor Truck Co. This position places him in charge of the field service, service and new truck test departments. He was previously assistant manager of the field service department, then headed by **R. H. KASPER,** who recently retired.

Bullock will present a paper at the Milwaukee meeting.

WILLIAM C. LEINGANG, general manager of the Stokes Molded Products Division, Electric Storage Battery Co., retired September 1 after 38 years' service. Previous to his latest position he was assistant to the president.

ERLE MARTIN, vice-president for research and development at United Aircraft Corp., will serve as coordinator for five scientific advisory committees composed of internationally known scientists and executives to provide counsel in fields pertinent to the interests of the corporation and its subsidiaries.

Among the scientists is **IGOR I. SIKORSKY,** designer of this country's first successful helicopter, and a consultant to United Aircraft.

PERRY W. PRATT, the corporation's vice-president and chief scientist is among four men who will represent United Aircraft.

JAMES E. PETERSON has been named assistant general sales manager of the Mechanics Universal Joint Division, Borg-Warner Corp. Peterson has been associated with Borg-Warner for a year. Formerly he was a product sales manager with Dana Corp.

D. A. WEAVER, formerly of the Public Safety Institute at Purdue University, has joined the Training Division of the Traffic Institute, Northwestern University, Evanston, Illinois. There he will direct special Institute courses for the Army, Navy, Air Force, and American Association of Motor Vehicles, as well as the Institute's traffic engineering seminars and workshops.

RAYMOND G. BENNETT is now associated with Novo Industrial Corp. where he is chief engineer for the United Air Cleaner Division. Bennett was formerly chief engineer, South Bend Division, Curtiss-Wright Corp.

Canfield

Graham

Knox

Howarth

Fernekes

Bullock

E. P. TIGHE has been made controller of the Aero Hydraulics Division of Vickers Inc., division of Sperry Rand Corp. He was formerly manager, corporate profit planning for Chrysler Corp.

JOHN C. MILES, professor of mechanical engineering at the University of Illinois, is on leave from the university to work in India for the U.S. International Cooperation Administration. In cooperation with the Government of India he will develop engineering curriculms for Indian engineering colleges.

ROBERT O. BABCOCK, manager of the transportation department of Consolidated Edison Co. of N. Y., Inc., retired on August 1. He had been with the company for 45 years, serving in wide variety of positions until his appointment in 1948 as transportation manager.

HENRY JENNINGS, a Past SAE Director, has moved to Fort Meyers Beach, Florida, where he will continue his fleet consulting work, mostly in the Southern states. He is no longer a member of Anthony B. Cassedy and Associates. "If I am lucky, he writes, "I'll get in some fishing, too."

MOORMAN R. BALIS has been appointed manager of fluid power equipment sales, Bendix Products Division, Bendix Corp., South Bend, Ind. He was previously contracts and planning director of the Bendix-Mishawaka Division.

LEONARD J. NOWIKOWSKI, director of manufacturing research, Metcut Research Associates Inc., has been elected to the executive committee of the Cincinnati chapter of the American Society for Metals. Nowikowski is currently project monitor for a Mecut contract concerning all types of machining studies on refractory materials.

ROBERT W. DARGUE, formerly with B. F. Goodrich Co., has joined the Presstite Division, American-Marietta Co. as Manager, Rubber Products Sales.

ROBERT G. LAWRENCE, formerly a service engineer at John Deere Ltd., is now associated with Consumer's Cooperative Refineries as plant engineer.

Awarded . . .

Jerome Lederer

JEROME LEDERER, managing director of the Flight Safety Foundation, Inc., is to be the recipient of the 1961 Daniel Guggenheim Medal in recognition of "his lifelong dedication to the cause of flight safety and his constant and untiring efforts to reduce the hazards of aviation." The SAE, the American Society of Mechanical Engineers, and the Institute of Aerospace Sciences are joint sponsors of the Award. SAE members of the Award Committee which chose Lederer were **W. F. BALLHAUS** and **E. J. MANGANIELLO.**

Prior to the founding of the Flight Safety Foundation, Lederer had been director of the Safety Bureau of the Civil Aeronautics Authority, having been named to that post when the Bureau was first set up. A member of SAE since 1926, he is a native of New York City, and a graduate of the College of Mechanical Engineering of New York University. As far back as the late 20's, Lederer — then an aeronautical engineer for the U.S. Air Mail Service — was investigating accidents and making changes in design of air mail planes designed to improve safety.

Presentation of the 1961 Award to Lederer will be made at a meeting of the American Society of Mechanical Engineers.

ROBERT C. LOMAN, formerly with Chrysler Corp. in their Sales, Parts and Service Divisions, is now vice-president of Career Resumes, Inc. Career Resumes, Inc. is a new organization and the first of its kind. They produce a word picture of a person's personal and job history which is used by those seeking employment much as a calling card is used to introduce a guest.

S. K. HOFFMAN, president and **T. F. DIXON,** vice-president of research and engineering of the Rocketdyne Division of North American Aviation, Inc., were honored by three West Valley, Calif. communities at the Woodland Hills Country Club as co-recipients of the 1960 Louis W. Hill Space Transportation Award.

The award was made in January by the Institute of Aerospace Sciences for "continuous leadership in development of extraordinary improvements in the thrust, efficiency, and reliability of powerplants for major ballistic missiles and space vehicle boosters."

Tighe

Miles

Babcock

Jennings

Krueger

Smirl

ALFRED A. KRUEGER has been named vice-presidet of sales and **RICHARD L. SMIRL,** vice-president of engineering at the Borg & Beck Division, Borg-Warner Corp.

Krueger, who has been associated with Borg & Beck for 40 years, was formerly sales manager and assistant to the general manager. Smirl has been with the division for 25 years, most recently as director of engineering.

Among SAE Enrolled Students

. . . who have entered industry

DALE C. ALM . . . General Motors Institute . . . engineer, Fisher Body Division, GMC.

DONALD J. ANDERSON . . . General Motors Institute . . . graphic engineer, engineering illustration & parts densification department, production engineering activity, Fisher Body Division, GMC.

EDWARD D. BARTLEY . . . General Motors Institute . . . project engineer, Harrison Radiator Division, GMC.

JULIUS F. BENE . . . University of British Colombia . . . mechanical engineer, Crown Zellerbach, Ltd.

GORDON L. BORST . . . South Dakota State College . . . facilities engineer, Boeing Airplane Co.

BILL J. CASTENHOLZ . . . California State Polytechnic College . . . development engineer, McCulloch Corp.

HELMUT F. CERNY . . . Wayne State University . . . associate engineer, Boeing Airplane Co.

JOHN CHIN . . . New York University, College of Engineering . . . application engineer, Western Electric Co.

RAYMOND L. CROSBY . . . General Motors Institute . . . student engineer, GMC, Linden, N. J.

RALPH A. De ECHEANDIA . . . The City College . . . project engineer, American Machine & Foundry Co.

CHARLES G. DIDEON . . . University of Washington . . . associate engineer, Boeing Airplane Co.

WILLIAM Y. ENDOW . . . Oregon State College . . . test engineer, Astronautics Division, General Dynamics Corp.

ALBERT E. FRY . . . Chrysler Institute of Engineering . . . material engineer, B. F. Goodrich Co.

DENNIS L. GOECKS . . . University of Wisconsin . . . engineer, The Martin Co., Denver, Colorado.

ERNESTO A. GROSKOPF . . . Wayne State University . . . stress analyst, Wettlaufer Mechanical Engineering Division, Pioneer Engineering & Manufacturing Co.

JOHN T. HARRIS . . . General Motors Institute . . . process engineer, Fisher Body Division, GMC.

STEPHEN J. HAYDOCK . . . University of Detroit . . . designer, Dana Corp.

TIMOTHY K. HASSELMAN . . . Carnegie Institute of Technology . . . test engineer, Convair Astronautics Division, General Dynamics Corp.

WELDON F. HEATH . . . University of Southwestern Louisiana . . . test engineer, George C. Marshall Space Flight Center, National Aeronautics & Space Administration.

PROF. K. H. WEIL (left), head of Mechanical Engineering at Stevens Institute of Technology, is making engineering come alive for his students by organizing a gallery of dramatic photographic studies depicting modern engineering processes and products. Major companies in this country and abroad are cooperating with Weil by providing striking engineering photos for the gallery. Interested spectator is M. L. Stoner, secretary, SAE Technical Board.

MUTSUMI V. HIROSE . . . Northrup Institute of Technology . . . maintenance engineering, Analysis Section, The Martin Co., Denver, Colorado.

ANTHONY R. KENT . . . California State Polytechnic College . . . hydraulic engineer, U. S. Geological Survey, Portland, Oregon.

WILLIAM F. KIMZEY . . . Parks College of Aeronautical Technology . . . service engineer, McDonnell Aircraft Corp.

LEONARD H. LUSTBADER . . . The City College . . . mechanical engineer, Marks Polarized Corp.

ERNEST R. MACH . . . .University of Oklahoma . . . mechanical engineer, Continental Oil Co.

KERVYN D. MACH . . . South Dakota State College . . . mechanical engineer, Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson AFB.

DEAN A. NELSON . . . University of Illinois . . . reliability engineer, Pontiac Motor Division, GMC.

JOHN S. NEVIN . . . Chrysler Institute of Engineering . . . test and development engineer, body components laboratory, Chrysler Corp.

RONALD J. G. NOVAK . . . Pennsylvania State University . . . associate engineer, The Martin Co.

HARVEY O. PATRICK . . . University of Miami . . . experimental engineer, Florida research and development center, Pratt & Whitney Aircraft.

ARTHUR POEHLMAN . . . University of Wisconsin . . . associate engineer, Douglas Aircraft Co.

ROY V. POGUE . . . California State Polytechnic College . . . design engineer, test equipment, Aerojet-General Corp.

JAMES RAWLINGS . . . California State Polytechnic College . . . program engineer, General Electric Co.

BERNARD H. RIS . . . Massachusetts Institute of Technology . . . design engineer, structure and suspension development, General Motors Technical Center.

ANDREW G. ROBINSON . . . Michigan College of Mining and Technology . . . plant engineering, Flint Manufacturing, Chevrolet Motor Division, GMC.

TERRY L. ROBINSON . . . Fenn College . . . engineer, Convair Astronautics Division, General Dynamics Corp.

PAUL ROSENBERG . . . California State Polytechnic College . . . mechanical engineer, Bacchus Works, Hercules Powder Co.

WILHELM D. SCHOENFELD . . . University of Toronto . . . engineer trainee, International Nickel Co. of Canada, Ltd.

J. C. SCHWANEBECK . . . Georgia Institute of Technology . . . associate

aircraft engineer, Lockheed-Georgia Co.

EDWARD H. SIMANEK . . . Milwaukee School of Engineering . . . Gas Distribution Division, Central Illinois Electric and Gas Co.

WILLIAM H. SINGLETON . . . Michigan State University . . . project engineer, Overseas Engine Division, Procter & Gamble Co.

EDDIE J. SMART . . . Indiana Technical College . . . engineering trainee, Tube Division, U. S. Steel Corp.

JAMES A. STEELE . . . Northrop Aeronautical Institute . . . associate engineer, Astronautics Division, General Dynamics Corp.

JACQUES VEZINA . . . Ecole Polytechnique . . . maintenance engineer, Hydro-Quebec.

DAVID L. WATKINS . . . General Motors Institute . . . engineer, central engineering, Fisher Body Division, GMC.

THOMAS A. WATSON . . . Purdue University . . . service department engineer, Caterpillar Tractor Co.

CHARLES M. WHITE JR. . . . Missouri School of Mines and Metallurgy . . . . associate tool engineer, Boeing Airplane Co.

EDWARD H. WIENS . . . University of Saskatchewan . . . Robin-Nodwell Manufacturing, Ltd.

. . . who have entered military service

HENRY J. BLANKENSHIP . . . University of Oklahoma . . . captain, U. S. Air Force.

RONALD A. EFKOWITZ . . . University of Pittsburgh . . . pilot, U. S. Air Force.

DAVID C. LYALL . . . University of Manitoba . . . Royal Canadian Air Force.

ARTHUR E. MULLER . . . Arlington State College.

DAVID J. PETTIGRASS . . . Syracuse University.

RICHARD A. WILLS . . . Missouri School of Mines and Metallurgy.

. . . who are doing graduate work

DONAT A. MARTINOLI . . . Ecole Polytechnique . . . graduate student at Illinois Institute of Technology.

MICHAEL E. HILLEY . . . Clemson College . . . continuing at Clemson as graduate student and instructor.

RICHARD F. TOZER . . . Case Institute of Technology . . . graduate student, Harvard University.

DEAN G. TRYON . . . General Motors Institute . . . graduate student, University of Michigan.

Obituaries

GENE C. BESSOLO . . . (J'60) . . . design engineer, missile department, Douglas Aircraft Co., Inc. . . . 1958 treasurer, Loyola University of Los Angeles SAE Student Branch. . . died May 20 . . . born 1936.

ALBERT E. BUCHHOLZ . . . (M'57) . . . senior project engineer, Outboard Marine Corp. . . . died January 11 . . . born 1916.

ERWIN C. HORTON . . . (M'35) . . . consulting engineer, Trico Products Corp. . . . died April 20 . . . born 1886.

FRANK RIPPINGILLE . . . (M'42) . . . supervisor, tractor test & development section, Ford Tractor & Implement Division, Ford Motor Co. . . . died July 2 . . . born 1912.

EDWARD R. SHARP . . . (M'46) . . . director emeritus, Lewis Research Center, National Aeronautics & Space Administration . . . died July 24 . . . born 1894.

E. GLENN SIMPSON . . . (M'18) . . . retired, formerly chief experimental engineer, Fisher Body Detroit Division, General Motors Corp. . . . died June 1 . . . . born 1885.

JOHN W. SPEAKER . . . (M'56) . . . president, J. W. Speaker Corp. . . . died November 22 . . . born 1903.

JOHN H. TABB . . . (M'51) . . . section supervisor, layout section, truck package layout & drafting department . . . Ford Division, Ford Motor Co. . . . died March 28 . . . born 1912.

MALCOLM THOMSON . . . (M'18) . . . retired, formerly consulting engineer, Thomson Laboratory, General Electric Co. . . . died May 4 . . . born 1891.

CHARLES W. VAN OVERBEKE . . . (M'43) . . . district sales manager, Western region, American Bosch Arma Corp. . . . died August 20 . . . born 1916.

SUMER WOLF . . . (M'52) . . . manager, engineering and development, Montreal Locomotive Works, Ltd. . . . died July 2 . . . born 1913.

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CRC Issues Octane Ratings for 1960 Cars

THE Coordinating Research Council's octane number requirement survey of 1960 production cars is now available from SAE as CRC Report 353, "Octane Number Requirement Survey 1960."

This 108-page report is a compilation of data on 507 cars obtained from 27 laboratories. Of these, 386 cars were chosen in proportion to their registration. The remainder consisted of 25-car samplings of selected models. Results show:

- Estimated octane number requirements of full-boiling range reference fuels for 1960 cars is lower than for 1959 cars.
- Tendency toward high-speed knock with full-boiling range reference fuels remained the same with approximately 10% of the cars exhibiting maximum knock at or above 2,350 rpm in both 1959 and 1960 models.
- 10% of the cars tested in 1960 had maximum requirements at part throttle compared with 6% of 1959 cars.
- Knock on tank fuel was reported by owners for 20% of all 1960 cars, but test observers found it to be 32%.

The 1960 survey is the 13th in an annual series on overall octane requirements and the 4th in which new-design and special-interest models were included.

■ **To Order CRC Report 353 . . .** from which material for this article was drawn, see p. 6.

Army Ordnance Seeks All-Purpose Brake Fluid

Based on paper by

C. F. PICKETT

U. S. Army Ordance Coating and Chemical Laboratory

ARMY Ordnance would like to see a single, polar-type, hydraulic brake fluid developed to serve for packaging, standby storage, heavy-duty, and Arctic operations. It now has three fluids —a preservative limited operational fluid, heavy-duty, and Arctic grades.

In view of the trend toward higher-temperature operation, it would help if suitable properties to meet it were included in this single fluid or, if that is impossible, added to the present heavy-duty fluid. Brake fluids having considerably higher boiling points have been made and examined, but they have proved more difficult to inhibit against corrosion. Furthermore, they show a fast drop in boiling point with the addition of small percentages of water.

It is well recognized that brake fluids

(continued on page 129)

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(continued from page 127)

do take up some water during the normal operation of a vehicle, and the figure may go as high as 5%. Even with half this amount of water the so-called high-temperature fluids drop back very close to the boiling point of the heavy-duty fluids with a like amount of water.

Another possibility for the future is a mineral fluid or mineral-type fluid such as MIL–H–5606. Mineral-type fluids have a very wide temperature range of operation. Oils such as MIL–H–5606 are fluid at – 65 F and yet have flash points considerably in excess of our heavy-duty brake fluid. Their nonpolar characteristics make them suitable for packaging and standby storage.

Mineral oil has shown one fault in field tests. It has no tolerance for water. Tests in a desert revealed the accumulation of a small amount of moisture in the master cylinder caused by the normal breathing action of the assembly. Upon standing, the water settled to the bottom to cause corrosion. These small pits would have caused eventual cutting or gouging of the rubber cup. Acrylonitrile-type cups were used in this test and were found to be completely satisfactory with mineral oil fluid. This problem points to a closed system as being, perhaps, better than our present breathing-type of master cylinder or, as an alternative, making mineral oil fluids tolerant to a small percentage of moisture.

Rubber Cups Could Be Improved

Ordnance would also like to have synthetic rubber cups that meet all military requirements. Existing types are prone to cause a high degree of corrosion at the interface of the cup with the cast-iron wall. Cold temperature operation of synthetic cups has been noticeably bad from the standpoint of leakage. The cups tend to take a cold set, become distorted in shape, and do not give a proper seal.

■ **To Order Paper No. C2 . . .** from which material for this article was drawn, see p. 6.

Zinc Primers Slow Passenger-Car Corrosion

Based on panel report by

R. E. WICKHAM
Jones-Dabney Co.

ZINC-RICH PRIMERS are successfully controlling passenger-car corrosion. This is particularly significant in the case of the unitized body, the strength of which cannot be jeopardized by premature corrosion without inviting disaster.

Zinc-rich coatings contain a high

(continued on page 130)

the secret of Ford's swing-away wheel

The secret of the new swing-away steering wheel in the Ford Thunderbird is a flexible shaft between the stub shaft in the steering gear box and the upper steering rod.

Here are the benefits derived from flexible shafts:

1. *Safety.* Safety against failures is provided.
2. *Durability.* Flexible shafts eliminate the possibility of play or lost motion at this juncture for the life of the car.
3. *Compact.* The flexible shaft is more compact than conventional joints.
4. *Strength.* In case of power steering failure, the maximum torque would be 660 pound-inches, which would occur during parking on dry pavement. The flexible shaft can absorb this and *much more.*

Here is another example of creative engineering with flexible shafts. Investigate for yourself how they can solve many of your design problems and at the same time reduce costs.

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(continued from page 129)

percentage of finely divided zinc dust dispersed in one of many suitable binders. Normally these coatings contain 90–95% by weight of zinc metal based on the dry film. Automobile manufacturers have selected this primer because of its weld-through properties and for the cathodic protection afforded to ferrous metals.

The theory of cathodic protection can be explained in this way: two metals are joined together and immersed in an electrolyte. A galvanic cell is formed and metallic ions go into solution from the anode (in this case, zinc), while the cathode (steel) remains unchanged. Obviously, the sacrificial protection afforded by zinc would be expensive and short-lived if full, continuous electrolytic action took place. Fortunately, in the most conductive zinc coating atmospheres the action eventually deposits on the steel substrate and the zinc primer itself a complex of zinc hydroxide or, in some cases, zinc carbonate which slows up further reaction by weakening the flow of current. Also, the precipitates themselves offer barrier protection to the steel.

Zinc primer is applied by brush or spray to film thicknesses of 2–5 mils, covering areas most susceptible to corrosion, such as welded joints, flanges, inner door panels, wheel housings, and other road-dirt and moisture-collecting areas. Zinc-rich coatings have been successfully applied over mill oil surfaces, demonstrating good adhesion after a 15-min, 350 F bake schedule and excellent salt-spray resistance.

Laboratory tests show little difference in the cathodic protection between zinc-phosphate-treated steel and steel with oily surfaces. This same protection can be obtained when the zinc primer is applied over wiped surfaces of drawing compound. Salt-spray corrosion tests show that zinc overspray on a zinc phosphate surface produces blistering after subsequent coats of primer and baking enamels. Extreme caution must be exercised to prevent this from occurring on the exterior surfaces of the automobile.

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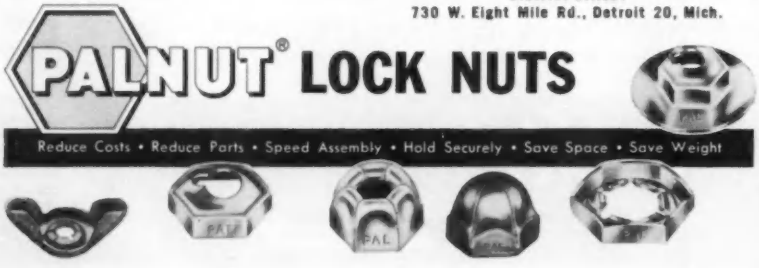

How to Insure Die Casting Success

Based on paper by

RICHARD STENBERG
Johnson Motors Division,
Outboard Marine Corp.

CONCERNS undertaking aluminum die casting for the first time can save themselves from headaches and possible failure if they make sure they have the following:

- Some experienced personnel.
- Proper casting design.
- A suitable labor contract.
- Properly designed die cast dies and tools.
- A building constructed for die casting.
- Maintenance facilities for dies and machines.
- A good quality control program.

Good operators are hard to find, but you must have at least a few men experienced in the type of machine to be used, the alloys to be cast, and the type and purpose of the die castings to be produced.

Good casting design depends on the competence of the engineer, and men who really know the business are in short supply. With the very first line placed on paper, the engineer begins to determine cost, weight, tooling expense, number of parts per hour, and maintenance expense. Unless the designer knows his job, the program will fail.

Existing work rules and contract provisions don't always fit die casting. Inconsistent and interrupted operation of a die cast machine can result in poor quality castings, high scrap rates, and high maintenance. Fit needs into the labor contract and avoid trouble.

In building a die casting die one can be penny wise and pound foolish. A

(continued on page 133)

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(continued from page 130)

moderate extra expense for steel to insure serviceable dies is usually a sound investment.

Heat, smoke, and fumes are a normal accompaniment of die casting and buildings should be constructed to be fireproof and capable of proper ventilation. Existing buildings rarely meet requirements.

Proper maintenance of dies and machines is essential. Few machine tools require the "fine tune" of the hydraulic system of a die cast machine. Maintenance personnel must understand their job and do it properly or castings will be of poor quality.

A complete program of quality control is as essential to a die cast plant as is the die cast machine or the die cast die. Quality control is a profession in its own right. The casting inspector should have a reasonable knowledge of how the casting is to be used and what subsequent machining and finishing will be required. It is wise to have records and an inspection guide to enumerate the conditions to be kept under surveillance.

■ **To Order Paper No. 389C . . .** from which material for this article was drawn, see p. 6.

Malleable Iron Rings Cause Cylinder Scuffing

Based on paper by

GEORGE C. LAWRASON
Southwest Research Institute

JOHN F. RAINOSEK, JR.
Kelly Air Force Base

and WILLIAM P. WISDOM
Pennington Channelcromium Co.

THE PRIME cause of scuffing of R-4360 Pratt and Whitney chrome-plated cylinder bores has been found to be the malleable iron rings of the type supplied by the Air Force which are incompatible with the bores.

These rings may be serviceable in steel cylinder bores, but their margin of scuff resistance is far less than that of grey cast-iron rings. Alloyed cast iron and AMS-7310 ring materials are satisfactory from the standpoint of compatibility, and the alloyed type has superior strength.

Overhauled cylinders, chrome-plated to MIL-C-7460, are serviceable as supplied to the Air Force, but the addition of a light electrolytic etch to MIL-C-7460 will add a small margin of safety to scuff resistance.

The investigations which led to these conclusions were carried on with a single-cylinder, Pratt and Whitney test engine which proved to be an ideal tool for examining R-4360 ring-piston-cylinder assembly performance. Although it is not easy to compare severity with the full-scale engine, it was possible to duplicate the scuffing phenomenon experienced in the full-scale engine.

None of the "fixes," such as assisting the break-in with additives in the lubricating oil, baked on the cylinder, or applied to the piston rings, was effective in eliminating the scuffing tendencies of the malleable iron rings. On the other hand, even accelerated break-in procedures failed to promote scuffing when cast-iron rings were used.

■ **To Order Paper No. 373A . . .** from which material for this article was drawn, see p. 6.

Magnetic Fields Fabricate Parts

Based on report by secretary

ARTHUR R. GARMENDIA
Grumman Aircraft Engineering Corp.

MAGNETIC FORMING of parts is accomplished by using two magnetic fields — one created by a round core in the center of a chamber, the other created around the outside of the chamber.

A part inserted between the two magnetic fields remains in static equilibrium since it is subject to an equal force from both fields.

By suddenly collapsing one of the fields the part is drawn, at extremely high speed, into the remaining field where it takes on the shape of any die placed in its path.

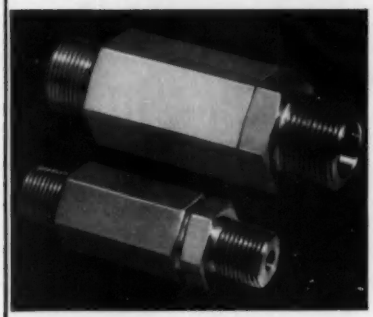
Based on report of discussion at panel on Production Fabrication Processes — N. A. Williams, Grumman Aircraft Engineering Corp., chairman.

Tests for Transmission Fluids Up-Dated by CRC

THE recently up-dated CRC research technique for determining oxidation resistance and thermal stability of power transmission fluids is detailed in CRC Report 352, "Reproducibility of Research Technique for Determining the Oxidation Resistance and Thermal Stability of Power-Transmission Fluids." In addition to describing the latest test procedures, the 60-page report summarizes test programs leading to the modification of CRC Designation L-39 (predecessor of the new L-39-361).

■ **To Order CRC Report 352 . . .** from which material for this article was drawn, see p. 6.

KOHLER PRECISION CONTROLS



New high pressure, in-line, relief valves with low hysteresis

MATERIAL—Aluminum, Steel, Stainless Steel
CONNECTIONS—All Types
WORKING PRESSURE—1500 to 3000 PSI
PROOF PRESSURE—2250 to 4500 PSI
BURST PRESSURE—3750 to 7500 PSI
OPENING PRESSURE—0 to 2250 PSI
RESEAT PRESSURE—10% Below Opening Pressure
LEAKAGE—0 at Reseat Pressure

• • • • • • • •

Ultra-sonic cleaning facilities. Kohler valves and other precision parts are assembled, tested, and packaged in dust controlled areas for minimum contamination.

Complete facilities in one plant, under unified supervision, insure reliable quality control and prompt deliveries. Kohler valves, fittings and parts are used by leading manufacturers for industrial equipment, automotive, aircraft and missile applications. Write for catalog.

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There's an R/M friction part in every make automatic transmission

. . . because only Raybestos-Manhattan makes all types of friction materials! For example:

- **Sintered metal plates**
- **Semi-metallic plates**
- **Cellulose plates**
- **Woven band lining**
- **Molded band lining**
- **Semi-metallic band lining**
- **Cellulose band lining**
- **Plastic friction dampeners**

What does this mean to you? It is your assurance of an unbiased recommendation of the material best for your application.

In addition, you can count on R/M for uniformly high quality; reliability of supply; prompt and extensive engineering, research and development assistance; competitive prices.

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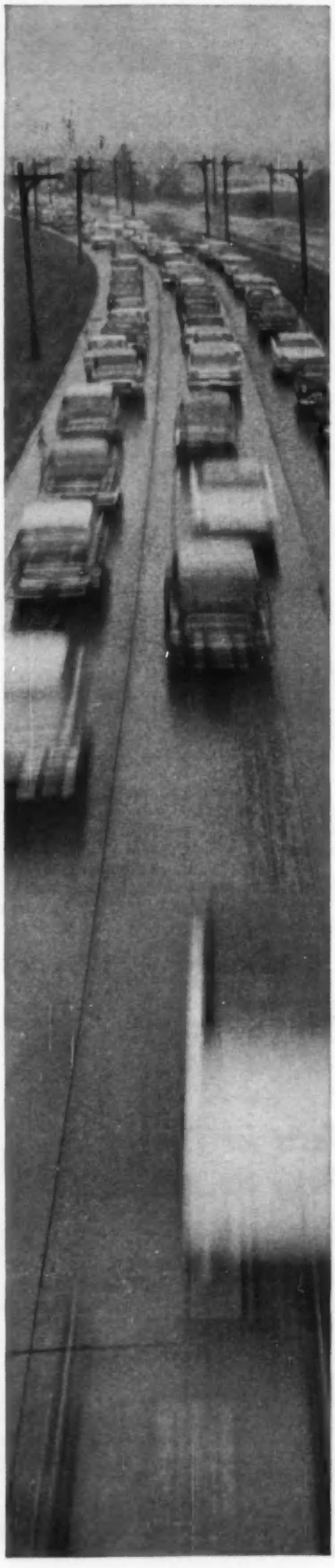

New Members Qualified

These applicants qualified for admission to the Society between July 22, 1961 and August 22, 1961. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group: Delmer Charles Stitt (A).

Buffalo Section: John Albert Adamek (J), Robert Wilson Bowler (M).

Central Illinois Section: Norman John Glomski (J), William A. Mitchener (J), Lloyd Ernest Terry (J).

Chicago Section: E. Eugene Bruning (J), F. William Foss (M), Ralph Cooley Herdrich (A), Myron Reynold Holmgren, Jr. (J), Robert Jack Melnick (J), John Milton Moran (A), Patrick Lee Powell (A), William George Rogal (M).

Cleveland Section: Derek Dawson (M), Harold A. Frost (M), Norman C. Jackson (M), Loran Edwin Manning (M), Gordon F. Somers (A), Gene David Wall (J).

Colorado Group: William Edward Zebley (J).

Dayton Section: Ronald Jerry Coleman (A), Robert Hall (J), Byron Warren Koch (M), Howard C. Sunderman (M).

Detroit Section: Bernard Adinoff (M), Thomas Harry Baylis, Jr. (M), Marvin S. Blemly (A), David Garrett Boone (J), James Reed Brown (J), Allen Keith Carpenter (M), William Lee Carpenter (M), George W. Code (A), C. A. Degucz (M), Curtis Frank Druckrey (J), Myron Phenando Ellis (A), Harry John Foehringer (M), Robert William Gillison (A), J. Ernest Gross, Jr. (A), Francis E. Heffner (M), Arthur William Hesskamp (J), Byron H. Hooker (M), Peter Kalil (M), Norman Stout Knauss (A), James C. Louton, Jr. (J), Marvin Allen Maten, Jr. (J), Frederick Stephen Murley (J), Edwin Arter Norris (M), Howard Dean Peacock (M), D. Rene Politis (M), Joseph Bengamin Reineke (A), Jerome Robert Singer (M), Donald Casteel Stoeckel (J), Thomas Harold Wendt (J).

Fort Wayne Section: Robert William Kickel (A).

Indiana Section: Norman Rush Brock

(M), Robert Allen Cheetham (M), James D. Coffelt (A), Harold Vernon Elliott (M), Calvin S. Kunkle (J), William Merton Scott (A).

Kansas City Section: Gene S. Hendricks (A), E. R. Howell (A).

Metropolitan Section: Lawrence W. Bierman (A), Henry Joseph Goffi (J), Irwin Gray (J), Angus McPherson Laidlaw (A), Gerald Richard Martas (J), William M. Morrison (A), Michael C. O'Connor (A), Richard Charles Sasse (M), Ray Livingston Vroome (M).

Mid-Michigan Section: Louis N. Capatanos (M), Robert J. Ruggles (M), Thomas R. Wiltse (M).

Milwaukee Section: Richard Robert Booy (M), James John Carravetta (A), James F. Effiandt (M).

Montreal Section: John Anderson (M).

New England Section: John E. Calley (A), James E. Cumming (A), Frederic G. Davis (A), Joseph Edward Dwyer (A), John Ward Harrison (M).

Northern California Section: Roy Beardall (A), Daniel Curtis Durie (J), Robert Alan Escobar (J), George Semones Kent (M), Arthur Stoneman Pedrick (M).

Northwest Section: Robert Daniel Hayes (A), Raymond Howard Rockstead (J).

Ontario Section: Charles Douglas Metcalfe (M), Borge Rommelhof Reimer (M).

Philadelphia Section: Donald John Raphael (A).

Pittsburgh Section: E. G. Delestienne (A), Eber W. Gaylord (M), William Donald Lion (M), Robert Earl Quigley (J).

St. Louis Section: James John Rezny (J), 2/Lt. Edward C. Sarlls (J), David Edward Taylor (J).

Salt Lake City Group: John Jacob Brunner (J).

San Diego Section: William Roy Wodell (J).

South Texas Group: Leonard Monroe DeMasters (A).

Southern California Section: Russell Daniel Barnes, Jr. (J), Zola Fredrick Carper (A), Patrick John Imbriano (J), Don C. Lougheed (A), Keith L. Mackie (J), James Parry Oakes (J), Robert L. Scott (J), Elmer Francis Ward (M), Thomas Francis Warren (A).

Texas Section: Ernest Victor Bunata (J).

Texas Gulf Coast Section: Gordon Koehl Morgan, Jr. (A).

Twin City Section: Donald E. Glesmann (J), Edgar M. Resel (A).

Washington Section: Maurice Herbert Wright (A).

Western Michigan Section: Mervin Russell Patterson (A).

Outside Section Territory: Carl Joseph Anglin (J), Joseph Fernand Blais (A), Edwin Francis Kalvin (M), Nathaniel Dare Lamberson (M), Allen Leroy Summers (M).

Foreign: Frank App, Jr. (M), Saudi Arabia; Raul Oscar Capuano (M), Argentina; Hans Hessler (M), Brazil; Francesco Lanzara (M), Italy; Jambunathan Venkataraman (J), India.

Applications Received

The applications for membership received between July 22, 1961 and August 22, 1961 are listed below.

Atlanta Section: Joseph Christian Schwanebeck

British Columbia Section: John Kemble Foster

Buffalo Section: Charles Edwin Fisher, Donald D. Hipwell, Bruce D. Kellner, Edward Lawrence Maguire, Jr., William Edward Rogerson, Frank Romaniw, Frank Edward Sapecky, Seymour Seigel, David Alfred Sterry

Central Illinois Section: Dave Henry Eber, Ralph Edward Jones, Walter Edgar Knepp, Robert LaVerne Malcolm, Ibrahim Nicola Nijmeh

(continued on page 137)

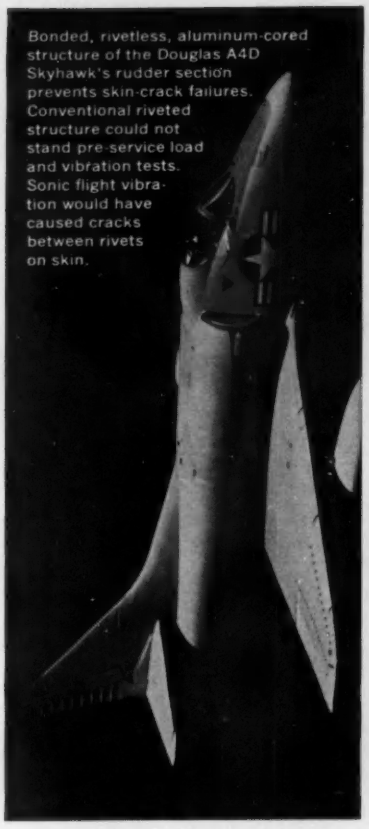
Bonded, rivetless, aluminum-cored structure of the Douglas A4D Skyhawk's rudder section prevents skin-crack failures. Conventional riveted structure could not stand pre-service load and vibration tests. Sonic flight vibration would have caused cracks between rivets on skin.

Photo courtesy Douglas Aircraft Company, Inc.

11 Ways Ray-BOND Adhesives Solve Tough Fastening Problems

New bonding and laminating techniques at R/M help solve difficult fastening problems and thereby make possible many of the new products being developed and produced by America's advancing technology. The advantages of Ray-BOND adhesives include:

Rivets can be eliminated • Members too thin to rivet can be joined and fixed • Manufacturing costs are reduced • Life of wearing surfaces is extended • Heat conductivity is improved • Weight reduction is substantial • Load is uniformly distributed over joint area • Bond produces residual elasticity • Complex shapes can be easily fabricated • Electrical non-conductivity and protection against corrosion can be achieved • Methods of application are fast, economical, flexible

Counsel and detailed technical information regarding the selection and application of adhesives are freely available to you from Raybestos-Manhattan. An R/M representative can call on you promptly to discuss your requirements.

MAIL COUPON FOR FREE BULLETIN

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Adhesives Dept., Bridgeport, Conn.

Please send me a free copy of your new technical Bulletin No. 701.

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BLOOD BROTHERS jointed steering assembly guides giant LeTourneau-Westinghouse coal hauler!

No matter how large the equipment you design, there's a Blood Brothers steering or jointed driving assembly big enough to do the job. One example of large size Blood Brothers components is the L6S Steering Assembly used on the LeTourneau-Westinghouse Haulpak Coal Hauler.

This mammoth, highly maneuverable "mountain mover" is a bottom-dump 450 h.p. diesel unit that weighs 37 tons. Yet it carries 2½ *times* its own weight in payload, or the equivalent capacity of over one and one-half standard 50-ton railroad cars!

Rockwell-Standard's Universal Joint Division offers you a wide range of specialized engineering experience–involving everything from manual steering assemblies . . . to power take-off drives . . . to heavy-duty propeller shafts. Whatever size and type equipment that you have in the planning or design stage, Rockwell-Standard can save you time, money – help you achieve higher standards of performance. Let us prove it–on your project!

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CORPORATION

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Applications Received

Continued

Chicago Section: Earl Thomas Acton, Richard J. Binder, Carl Martin Bloom, Joseph James Castronovo, John Thomas Hall, John B. Helmer, Otto E. Johnson, Raymond Martin Larson, Andrew F. Raab, David W. Ryan, Joseph J. Walls, Eugene Barrett White, Jr. Allen D. Wolka, Richard Alan Young

Cleveland Section: John Patterson Fitzgerald, Jr.

Colorado Section: Wallace G. Martin

Dayton Section: Philip Virgil Monnin

Detroit Section: Albert N. Beswick, Lawrence D. Bischof, James Norman Ellis, Nels Leroy Hansen, Harold M. Haskew, Russell Clyde Holmes, Charles Richard Jones, Warren Frederic Kendall, James H. Kennedy, Victor John Kowachek, Rusi Furdoonji Kutar, Joseph Charles Littmann, Robert William Massberg, Richard V. Moxley, Lee Richard Musson, Joel Earl Peabody, Philip G. Robinson, Alex H. Samorek, Mitchell J. Simon, Donald Edward Stamp, John Patrick Thornton, Leo L. Vigi, Baird Wallace, David Lawrence Watkins, Warren Allen Wickland, Robert T. Woods

Fort Wayne Section: George Emory Hecox, John Edward Ruppenthal

Indiana Section: John James Misiolek, Jr., Donald Eugene Orem, Jack W. Schmidt, Charles B. Urban

Kansas City Section: James William Walker

Metropolitan Section: Mohamed Nour Eldin Aref, Harold Erich Bachman, Milton Carl Baxter, William George Burger, Raymond Lloyd Crosby, Herbert E. Peitzer, William Hubert Schank, Martin John Tustin

Mid-Continent Section: Joseph Robert Cook, Ernest R. Mach, Boyce Wayne O'Berg

Mid-Michigan Section: Robert L. Danek, Peter Pardee, David Warrington Piper

Milwaukee Section: Arnold C. Latus, Oscar Ernesto Stefanutti

Montreal Section: Emile Daumont, Malcolm Alastair Gray

Northern California Section: William Thomas Deibel, Hideo Furiya, Roy V. Pogue, James Charles Rawlings, Errol Francis Reilly, Louis Maurice Rorden

Northwest Section: John William Armstrong, Jr., James Vance Lyons, Vernon James Phelps, David Bruce Walker

Ontario Section: Bruce Malcolm Addison, Boyd Thomas Cochrane, Donald Michael Gillis, Kenneth O. Grant, John Edgar MacDonald

Philadelphia Section: William J. Huth, Laverne Ellsworth Sheckenbaugh, Thomas Victor Travaglini

Pittsburgh Section: Earl Richard Fowler, Carl Edwin Muir, Kenneth James Stauffer

Rockford-Beloit Section: Ronald Wayne Nicolaus, Edward Henry Simanek

St. Louis Section: Frederick Werden Balster, William Farley Kimzey, David O. Metz, Edwin Woodward Schisler

San Diego Section: George Hayashi

Southern California Section: James Stanley Arnold, John N. Calandro, John Phillip Edgar, Robert W. Jonasen, Andrew Krzyzanowski, Sterrett Metheny, John Warren Moers, Harold Edward Moore, Darrell Edward Rolison, Earle LaForge Scofield, Jr., George William Scott, Edwin Thomas Spencer, Dan L. Swannack

Southern New England Section: Reginald James Smith

Twin City Section: R. Frank Kehrberg

Western Michigan Section: Alex Heath, Carl V. vonLinsowe

Outside Section Territory: Edgar W. Almquist, James Edgar Bald, Donald Clyde Graesser, Jan Kerrebyn, Jr., David A. MacPherson, Oliver Percival Pederson, Bill Allison Tolson, Donald Henry Werle, Warren Milton Wiele

Foreign: John Harold Andrew, England; Javier Fuster Conrado, Spain; Oktay Mustafa Erenturk, Turkey; Hassan Mohamed Hassan, Egypt; Eugen Wilhelm Huber, Germany; Narottam Lall Jain, India; R. Ravi Kumar, India; Gubbi Solur Kumaraswamy, India; Pierre M. Lancrenon, France; Noritada Oishi, Japan; George W. Reynolds, Lebanon; Ludwig Rosenfeld, England; Jacob Harmen Wyker, South Africa

Spring silencers, heater ducts, and washer jars made of MARLEX* are low cost... improve performance

Tough, long-lasting, graphite-impregnated interleaf spring silencers . . . flexible and rot-proof heater ducts that resist tears and punctures . . . light, durable windshield washer jars that won't shatter or burst, and are unaffected by freezing or under-the-hood temperatures! These three original-equipment items are examples of the ever-increasing number of automotive components being made of MARLEX high density polyethylenes and ethylene copolymers.

The advantages of using these high density plastics are many—better performance, economy, easier assembly, and molded-in texture and color if required. Physically, MARLEX high quality plastics are light, tough, corrosion- and rot-proof, non-allergenic . . . resistant to acids, alkalies, oil, and grease . . . unaffected by extremes of temperature (-180°F to 250°F).

For more information on MARLEX, see your plastic fabricator . . . or contact us directly.

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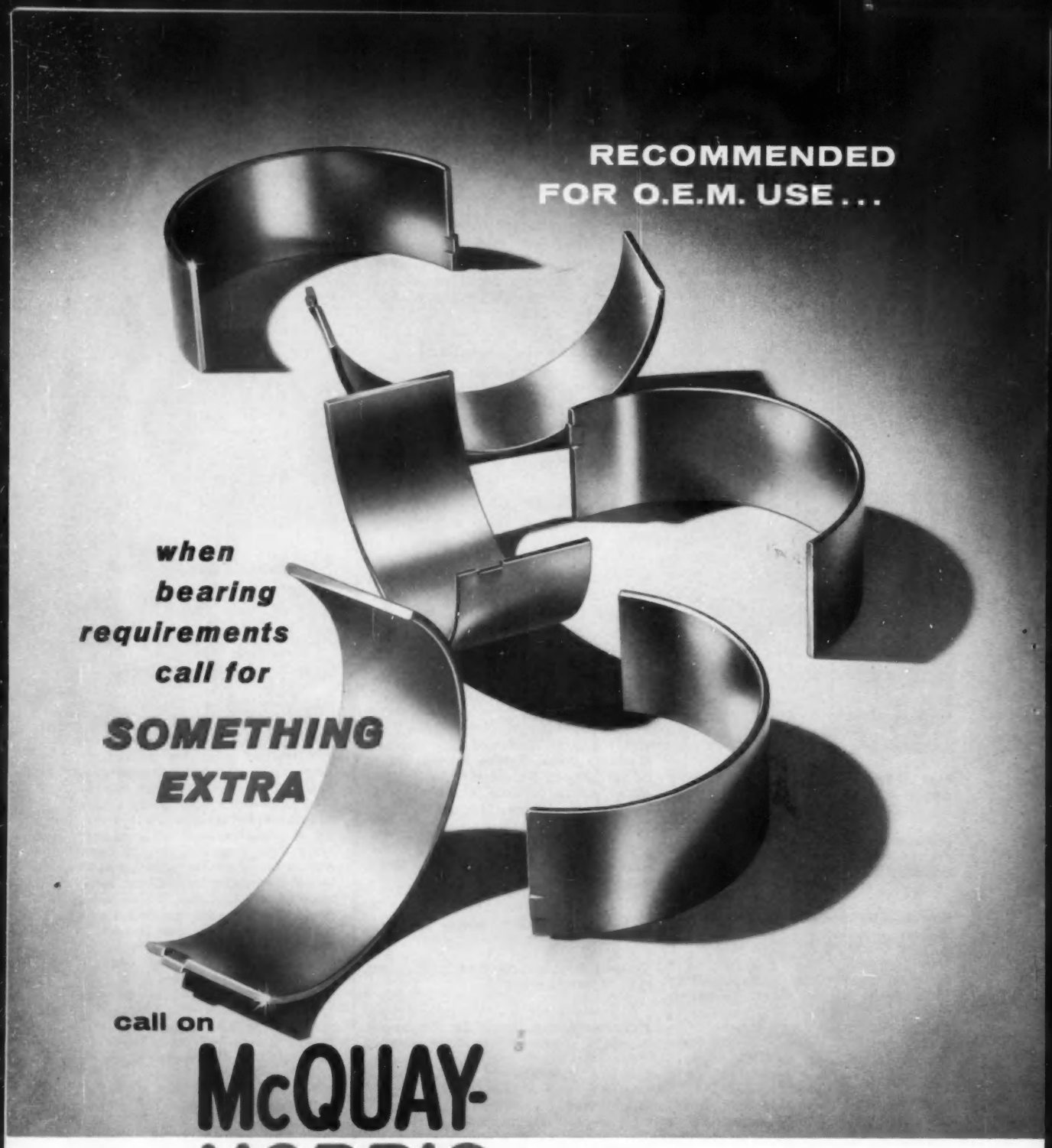

No matter what type of bearing — babbitt, sintered copper-lead, aluminum — McQuay-Norris makes 'em! And from our years of experience, you can be sure of that *something extra* in quality and performance.

McQuay-Norris bearings are made to S.A.E. specifications. They are precision designed to give superior service... cooler running... better heat transfer.

For stronger and longer bearing life, you can depend on McQuay-Norris bearings.

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KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

How Alloy Steels Respond to Induction Hardening

In the induction-hardening process, steel is first heated above the transformation range by means of electrical induction, then quenched as required. Special equipment is needed, and heat is developed as follows:

High-frequency alternating current passes through a coil or inductor, with the result that a magnetic field is created in the coil. When the piece to be treated is placed in this field, it is heated rapidly by induced energy. With the various types of induction-heating equipment, the process is capable of surface- or case-hardening to various controlled depths; however, through-hardening can be obtained with certain alloy steels. Ferrous metals that respond well to induction hardening include numerous grades of both alloy and carbon steels, as well as hardenable stainless steel and plain or alloyed cast iron.

As a rule, when alloy steels which contain non-carbide-forming elements, such as nickel, are heated by induction, the usual hardening temperatures can be used. But with alloy steels that do contain carbide-forming elements such as chromium, molybdenum, and vanadium, the hardening temperature must be increased if the normal effect of the alloying elements is desired.

Hardness obtained by the induction process is a function of the carbon content and prior structure, just as it is when conventional heating methods are used. Nevertheless, higher surface-hardness values for a given carbon content have often been noted in parts subjected to surface induction-hardening. The extra hardness may be as much as five Rockwell C points for steels of 0.30 pct carbon.

As pointed out previously, the induction method requires special equipment. However, it possesses several marked advantages, including speed of heating and cleanliness of operation. Pieces heated by induction are usually subject to a minimum of scaling and distortion. Moreover, induction-hardening equipment is very compact and therefore conserves floor space.

If you would care to know more about the induction hardening of alloy steels, please communicate with our technical staff. Bethlehem metallurgists have made a thorough study of the subject, including the many details of quenching and tempering. Call them if they can help you in any way. And remember, too, that Bethlehem makes the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

Steel

for Strength . . . Economy . . . Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

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New Light Heavyweight...

FULLER

Models 5-H-74 5-HA-74*

the lightest transmission designed for diesel engines—from 190 hp to 250 hp

In keeping with the trend toward high capacity, light-weight components, Fuller has released its new Model 5-H-74 5-speed Transmission.

The NEW 5-H-74 offers:

- * **Model 5-HA-74 . . . even *lighter* weight — 93 lbs. less — with *aluminum* case and clutch housing**
- **mainshaft of greater diameter**
- **high capacity mainshaft pilot bearing**
- **wide gear faces**
- **all helical gearing—low tooth pressures**
- **short, quick shifts—jaw clutch engaged**
- **short installation—25 11/14" in length**
- **extremely high ratio of capacity to weight**

SPECIFICATIONS
Gear Ratios

5th	1.00
4th	1.17
3rd	1.98
2nd	3.61
1st	6.60
Rev.	6.51

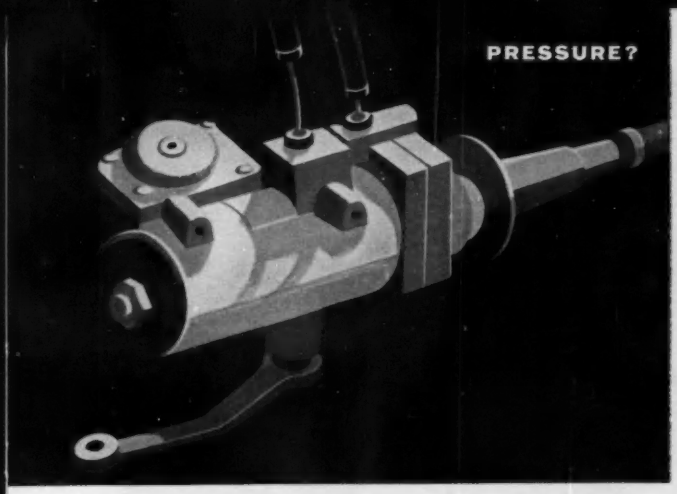
Weight:
Model 5-H-74—461 lbs.
*Model 5-HA-74—368 lbs.

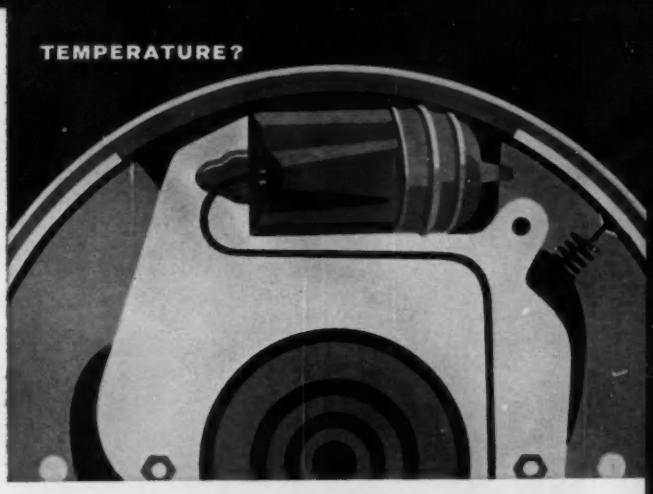
Oil Capacity: 12 quarts.

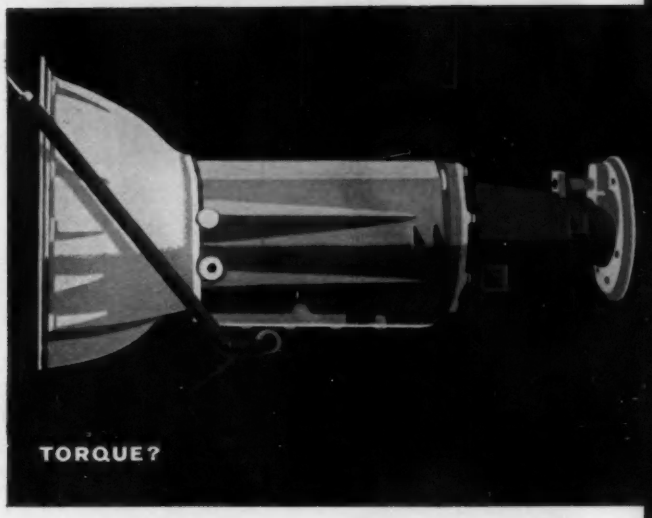
Length: 25 11/14 inches.

FULLER TRANSMISSION DIVISION
EATON MANUFACTURING COMPANY
KALAMAZOO, MICHIGAN

Sales & Service: West. Dist. Branch, Oakland 6, Cal. • Southwest Dist. Office, Tulsa 3, Okla. • Automotive Prod. Co., Ltd., Automotive House, Great Portland St., London W. 1, Eng., European Rep.







POWER PROBLEMS? . . . "tailored" hydraulic fluids meet new physical, chemical demands

New developments and designs in hydraulic systems frequently ask for fluid performances that aren't possible with present materials. And that's where the Dow Automotive Chemicals Laboratory can step in and "tailor" a fluid that will meet just about any physical or chemical need.

For many problems, a ready solution is frequently found by improving the existing formulation—for example, adding a thickener to alter viscosity characteristics. Other problems require a totally new material. Here's where the chemist has a special advantage—if he doesn't *have* the right fluid, he can *make* it! At the Dow Automotive Lab the chemists and automotive engineers are particularly well equipped to create new hydraulic fluids to extremely exacting specifications.

An example: a new Dow formulation was recently developed for a single central-power fluid to actuate steering, brakes, windows, and other accessories. To aid the Automotive Industry, the laboratory resources and experience are available to assist in particular problems.

With Dow's broad background in hydraulic fluid technology and a long list of glycols, Dowanol® glycol ethers, and other polyols, a ready answer to many hydraulic fluid needs may be achieved.

ENGINE COOLING. Ebullient cooling for passenger cars is under continuing research at the Dow Automotive Chemicals Laboratory. The increased flexibility of the system is expected to allow more freedom in the placement of radiators, for example, remote from their present location. This thought is intriguing to designers!

VORACEL® foamed-in-place, rigid urethane is showing real economic advantages over cut-and-paste batt applications. Application of the new water and chemical resistant foam may be either by a spray or pour operation for insulation, structural support, sound deadening, "pocket" sealing, and surface protection.

DOW AUTOMOTIVE CHEMICALS LABORATORY

Created expressly to serve the needs of the automotive industry, Dow's Automotive Chemicals Laboratory is active in technical service and development. This laboratory is continually researching and developing coolants, hydraulic fluids, cutting and grinding fluids, functional fluids, fuel and lubricant additives, and synthetic lubricants. To see how this laboratory can be of assistance to you, contact your nearest Dow sales office or write to Chemicals Merchandising in Midland.

THE DOW CHEMICAL COMPANY DOW Midland, Michigan

valve gear for any engine

Hydraulic and Mechanical Tappets (Barrel or Mushroom Type) of Alloy Steel, Hardened Alloy Cast Iron, Chilled Iron, or Alloy Chilled Iron • Push Rods • Adjusting Screws • Retainers

No matter what your valve gear requirements, it will pay you to check with Chicago's Tappet Division. For here you get the benefits of specialized techniques and facilities which, in 25 years of producing tappets and other valve gear, have established long records of trouble-free service . . . verified in over 25 million engines.

Chicago's special staff of tappet engineers can provide complete valve train designs for all types of engines . . . car, truck, tractor, diesel . . . aircraft, outboard, power mower, or industrial.

Their particular skill in development engineering will also prove a valuable addition to your own engineering staff. And the unique manufacturing and precision testing facilities especially developed by Chicago for valve train production provide you assurance of dependability and long life.

Whatever your valve gear problem, just call Chicago's tappet engineers today. You will find it advantageous to contact Chicago *while you are still in the preliminary design stages.*

THE CHICAGO SCREW COMPANY

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2701 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS

Independent planetary steering coupled to transmission permits positive power on both tracks of TD-25 crawler tractor. Transmission is built to last with gears of strong, tough AISI 4620.

Steeled to move mountains

Gears of AISI 4620 nickel alloy steel provide strength and stamina in the new International* TD-25 crawler.

Whether push-loading, dozing or pulling, the International TD-25 converts its full 230 hp to work power. On *all* these jobs, power train parts sustain severe shock, stress and compressive loading.

To give this big tractor built-in endurance, International engineers specify AISI 4620 (1.8% nickel) for critical transmission gears.

Gears made from carburized and hardened 4620 develop a strong, tough core beneath a hard case... withstand compressive loading up to 210,000 psi.

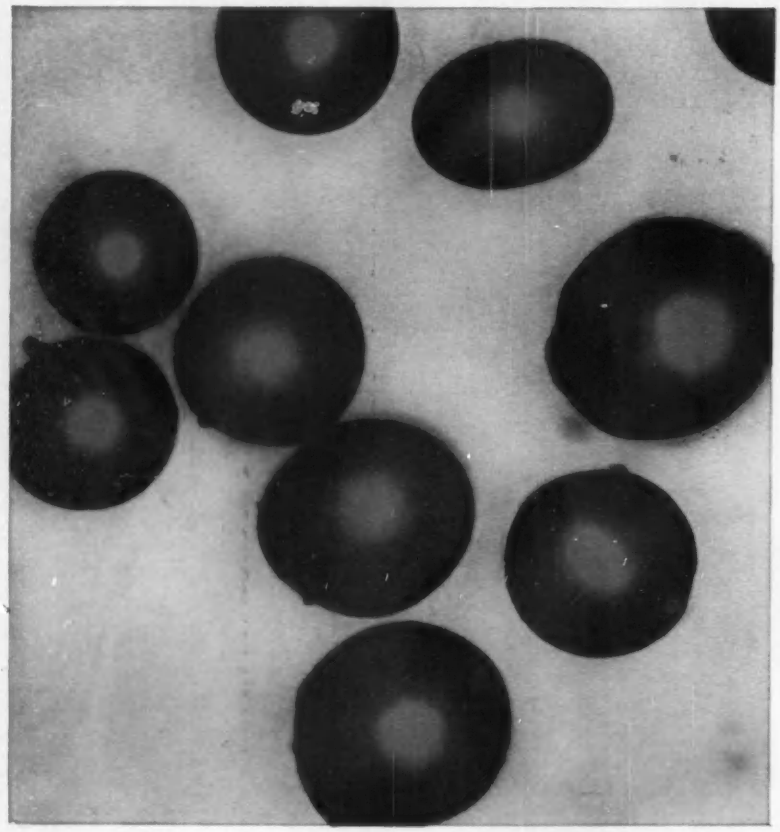
This is an example of how one nickel alloy steel is used for resistance to shock, fatigue and wear in construction equipment. For more information on the use of 4620 and other nickel alloy steels in 11 types of heavy construction equipment, write for a free copy of booklet "A-265." *T.M., International Harvester Co.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

30 MILLION OF THESE JET-FORMED SPHERES IN EVERY INCH OF BEARING SURFACE!



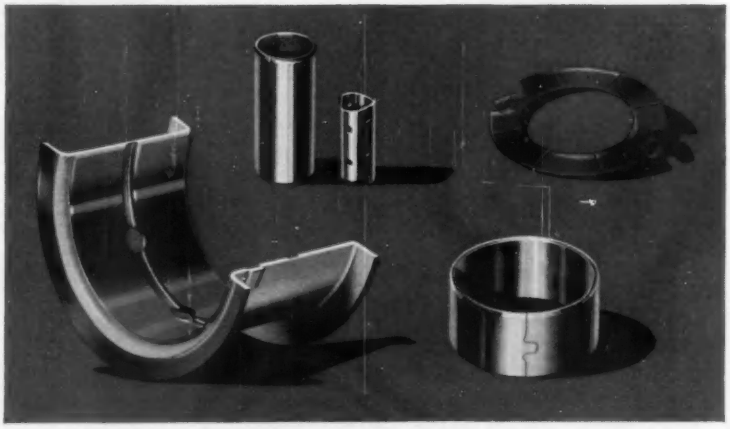
JET PROCESS BLASTS MOLTEN ALLOY INTO UNIFORM PARTICLES . . . so small that thirty million will form a thin layer only one inch square! This sintered layer is the bearing surface of Federal-Mogul sleeve bearings.

Molten copper-lead, alloyed to exact specifications, is poured into a special inert-atmosphere reaction crucible. Here it's blasted by a high-speed fluid jet to form the dense powder shown at left.

Because of the uniform particle size of this powder, the bearing surface of each F-M copper-lead sleeve bearing has precisely the same alloy composition and high adhesion to the steel backing as every other F-M bearing of the same alloy type!

YOU CAN SEE THE CONSISTENT SIZE in the photomicrograph. What you *can't* see is the consistent alloy composition which produces uniform bearing properties and performance in any alloy type.

Federal-Mogul makes engine bearings for every condition of speed and load. You can select from among five different sintered copper-lead alloys, all permanently bonded to precision-formed steel backing. Our Engineering Department is available to you for consultation or recommendations on bearing design and application. For more information, write Federal-Mogul Division, 11035 Shoemaker, Detroit 13, Michigan.



A COMPLETE LINE! Steel backed bearings with a selection of many different alloys for virtually any bearing application—Plain and bimetal bushings in bronze, steel or aluminum. Precision thrust washers in solid bronze, or sintered alloys on steel (one or both faces). Rolled split spacer tubes in steel, aluminum or stainless.

FEDERAL-MOGUL

sleeve bearings
bushings-spacers
thrust washers

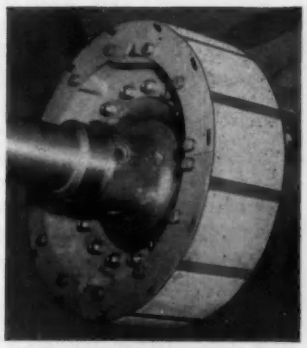
DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

This Michigan Tractor Shovel operates on hillsides and 30° slopes ...get stopping power with Hi-Torque brakes

Working on a Springfield, Mass., reservoir job, the Fruin-Colnon Contracting Company and C & C Construction Co. use this 6 yard Tractor Shovel for clearing, stripping, excavating, lugging 16-ton pipe sections, backfilling, and other work. The contractor reports: "These operations call for good brakes which this machine has ... BFG Hi-Torques are tops!"

Hi-Torque brakes are now supplied as original equipment on a wide range of heavy-weight vehicles: big dump trucks, tractor-scrapers, coal haulers, mine trucks, and other special vehicles. They provide up to 125,000 foot pounds of braking torque per brake in a smaller sized "package" than any other shoe brakes. Hi-Torque brakes cut stopping distance approximately in half, compared to conventional two-shoe brakes tested on identical vehicles and loads.

You can use these brakes in *your* heavy-duty vehicles with a minimum of design change. Available in seven basic sizes; operation air-over-hydraulic, or direct hydraulic. For complete information call or write *B.F.Goodrich Aerospace & Defense Products, a division of The B.F.Goodrich Company, Dept.SJ-10, Troy, Ohio.*



Hi-Torque brakes give *full-circle contact* around the drum for maximum stopping power. Brakes can be operated by air-over-hydraulic, direct-hydraulic, or direct-high pressure air actuation.

B.F.Goodrich **Hi-Torque brakes**

THEW LORAIN MOTO-CRANE

SEAGRAVE FIRE TRUCK

HENDRICKSON TRUCK CRANE

FWD LINE TRUCK

Whatever the job...

New G-21 Series Valves

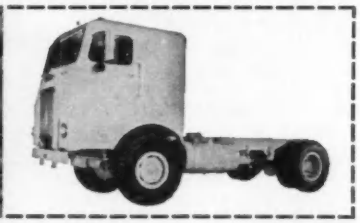
cut costs on

Garrison POWER STEERING!

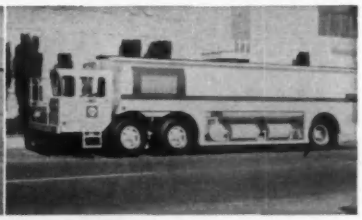
- **HEAVY DUTY VEHICLES**
- **HIGH SPEED TRUCKS**
- **OFF-HIGHWAY TRUCKS**
- **TRUCK CRANE CHASSIS**
- **MATERIALS HANDLING EQUIPMENT**
- **INDUSTRIAL LOADERS • ETC.**

KENWORTH TOWING TRACTOR

WHITE FREIGHTLINER



WHITE 5000



KW DART TANKER

Garrison now offers a new line of low cost, hydraulic power steering valves and cylinders! The G-21 Series cuts power steering costs because *you don't pay for something you don't need*... no waste in over-design, excessive materials, unnecessary labor. G-21 Valves now complement existing Garrison designs and permit proper selection of the most economical valve for any job, based upon vehicle usage, engine horsepower, axle loading and steering design linkage. Here's *custom-designed performance* with standard valves at important savings to you!

Garrison, originators of the "divided linkage" system of power steering, incorporates patented hydraulic reaction in all valve designs resulting in proportionate "feel," greater stability, excellent recovery and smooth, reliable performance. Furnished as standard equipment on many types of wheeled vehicles by major manufacturers, also available in kits for adaptation to existing equipment.

Whatever your steering application...

Get POWER with GARRISON!

GARRISON *Manufacturing Co. Inc.*

4609 East Sheila Street, Los Angeles 22, California

Multiple Lip Rod Seal with Wear Compensating Spring
Large Area Heat Treated Sintered Metal Rod Bearing
Patented Restricted Orifice With Intermediate Valving Gives 3-Stage Control On Rebound Valve
New, Improved Design Coil Spring Base Valve with Larger Intake Capacity

You bet your life on your shock absorbers

And so do drivers of cars you manufacture. As you know, shock absorbers do far more than cushion the ride. They hold wheels solidly on the road, control spring action, provide car stability. That's why it's important for you to specify shocks which give the greatest control for the longest time.

Monroe shock absorbers are engineered to extremely close tolerances, and an advanced coil spring design provides longest valve life of all shocks. Superior design makes Monroe shocks respond swiftly and sensitively to all road conditions and prevents premature wear.

Monroe shocks are the miles-ahead, year-after-year leader in replacement sales. So why not give new car buyers their preference as original equipment? Our engineers will be glad to give you the facts and figures on Monroe superiority.

MONROE
SHOCK ABSORBERS

MONROE AUTO EQUIPMENT COMPANY • Monroe, Michigan • *World's Largest Maker of Ride Control Products*

POWER STEERING • SWAY BARS • TRACTOR SEATS • SUPER LOAD-LEVELER® (stabilizing units)

Helping to make tomorrow's cars today . . .

Progress report on 4 high

NEW FROM BUDD—an advanced concept in the testing and design of automobile bodies brings road and proving ground *into* the laboratory. Shown here is part of an extensive, Budd-developed instrumentation system that can simulate hundreds of thousands of miles of travel, under the most rigorous conditions, in one-third actual road or proving ground time. In addition to providing quicker answers, laboratory environment permits easier, more accurate evaluation of results. New procedure is readily applicable to any automobile—can effect substantial savings in time and costs in the efficient design of new bodies.

A BUDD TECHNICIAN TESTS the application of adhesive for the bonding of automobile door components. As yet not widely used in the automotive field, adhesive bonding holds great promise for increasing flexibility in the manufacturing process—broadening choice of materials, such as aluminum and steel combinations, newly developed plastics, etc. In helping to overcome current problems, Budd research opens up a new method for producing a better product more efficiently and economically.

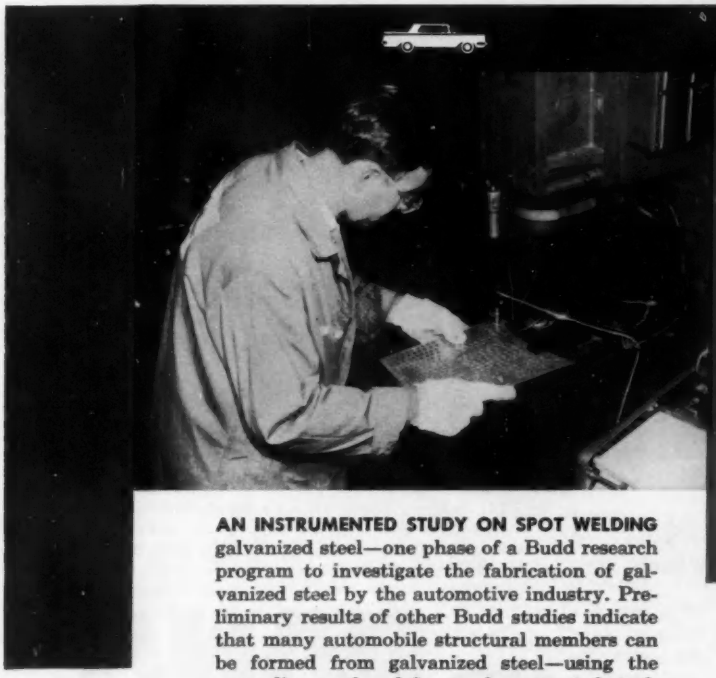
"AUTOPIA" a new sound film in color—tells the complete story of our automotive facilities. If you are interested in seeing this film, write on your company letterhead to Sales Department, Automotive Division, The Budd Company, Detroit 15.

The research projects reported here are but four of many currently underway at Budd that offer a high potential for the entire automotive industry. Objectives—to improve manufacturing procedures . . . increase quality . . . lower costs. As one of the largest independent automotive suppliers in the world, Budd has always sought new ways to provide better products. Past Budd research has paid off in such diverse areas as the all-steel body and current techniques of resistance welding used throughout the automotive industry. Such research is but one of the many ways Budd serves the automotive industry in helping "to make tomorrow's cars today."

potential research programs

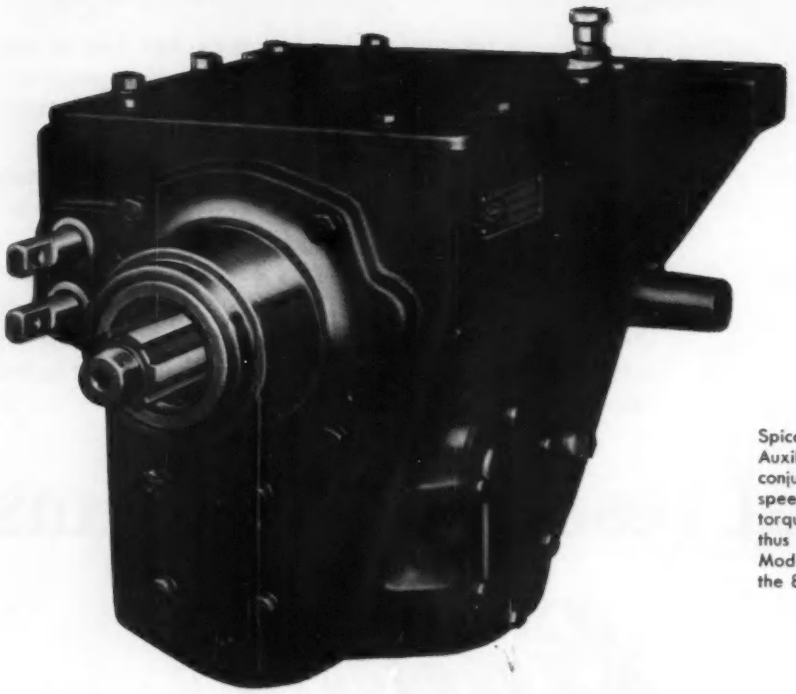
Budd Automotive

DETROIT • MICHIGAN



AN INSTRUMENTED STUDY ON SPOT WELDING galvanized steel—one phase of a Budd research program to investigate the fabrication of galvanized steel by the automotive industry. Preliminary results of other Budd studies indicate that many automobile structural members can be formed from galvanized steel—using the same dies employed for regular uncoated steel. Research of this kind will eventually lead to the mass produced, completely corrosion resistant cars of the future.

ULTRA-HIGH-SPEED PHOTOGRAPHY OF ARC WELDING PROCESS—part of Budd's study of new arc welding techniques, processes and equipment in order to broaden the knowledge of these methods in automobile body fabrication. A major objective—to exercise complete control of these processes as applied to high production quality welding. Eventual benefits to the industry will include greater fatigue resistance, savings on weight, reduction of rejects, much higher corrosion resistance.



Spicer's new Model 7041 4-Speed Auxiliary Transmission—for use in conjunction with standard 4 or 5-speed transmissions—has a nominal torque rating of 550-600 ft. lbs., thus narrows the gap between the Model 6041 (375-400 ft. lbs.) and the 8341 (750-900 ft. lbs.)

New Spicer 4-Speed Auxiliary Transmission For Engines in the 400-600 Ft. Lbs. Torque Range

Model 7041 Broadens Range of Spicer Line, Utilizes Maximum H.P., Is Quiet, Saves Weight

Now—Spicer has added a new model to its power line of 4-speed auxiliary transmissions—the Model 7041—whose 550-600 ft. lbs. nominal torque rating meets a vast need for engines developing over 400 ft. lbs. of torque.

The 7041 operates most effectively with main transmissions in the 400-600 ft. lbs. capacity range. Ratios in the auxiliary are spaced so that they functionally split or compound the ratios of the main transmission.

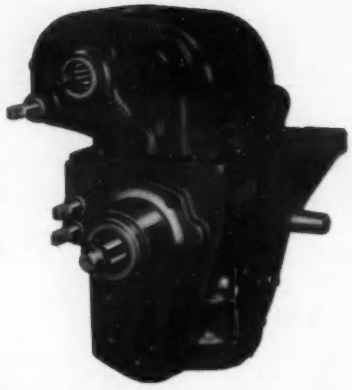
The new transmission has good splits in the top three gears, as the following table shows:

RATIOS	Model	1st	2nd	3rd	4th
	7041	2.31	1.21	1.00	.83

The result is that it is possible to utilize the maximum horsepower of the engine during shifts. In addition, the driver is able to complete shifts in these three splitter gear positions at the same R.P.M.

The new auxiliary transmission is also constant mesh in all gear positions, which makes for quieter operation and easier shifting due to the use of helical gears throughout. It is lighter and less bulky than any other 4-speed auxiliary transmission of similar capacity.

For complete data on the many advantages of the new Spicer 7041, write to Dana Corporation, Toledo 1, Ohio.



Spicer Top Mount Power Take-Off can readily be assembled to the 7041 Auxiliary Transmission by merely removing the cover, is ideal for operating air compressors, heavy-duty winches, large pumps, and other materials handling devices requiring full engine torque.

DANA Spicer **DANA CORPORATION**

Toledo 1, Ohio

SERVING TRANSPORTATION—Transmissions • Auxiliaries • Universal Joints • Clutches • Propeller Shafts • Power Take-Offs • Torque Converters • Axles • Powr-Lok Differentials • Gear Boxes • Forgings • Stampings • Frames • Railway Drives

Many of these products are manufactured in Canada by Hayes Steel Products Limited, Meritton, Ontario

BALL BEARING "HEARTBEATS"

checked with unique new fatigue tester

With a stethoscope checking the "heartbeats," this unique fatigue tester is putting BCA ball bearings through a battery of exaggerated, but controlled, speed and load tests.

The fatigue testing machines are part of a group of testing devices that provide essential data for BCA's research program. Hydraulically testing BCA bearings at a variety of rotational speeds and under many combinations of radial and thrust loads, each machine checks to see that BCA ball bearings are maintaining the highest fatigue life standards . . . evaluates the fatigue characteristics of new ball bearing materials and new processing methods . . . helps select ball bearing lubricants to provide the longest possible fatigue life.

These machines and BCA's other unusual testing devices are designed and built to help us develop the highest quality ball bearings available. By simulating actual operating conditions, BCA ball bearings can be tested to *exceed* customer specifications.

BCA ball bearings are standard equipment throughout industry—for both original and replacement applications. BCA's complete line of ball bearing types and sizes . . . design, engineering and manufacturing skill . . . plus research and testing facilities, are some of the reasons that automotive, machine tool, earth moving, agricultural equipment manufacturers specify BCA. We'd like to serve you—with high-performance bearings or technical assistance. Contact Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA

BEARINGS COMPANY OF AMERICA

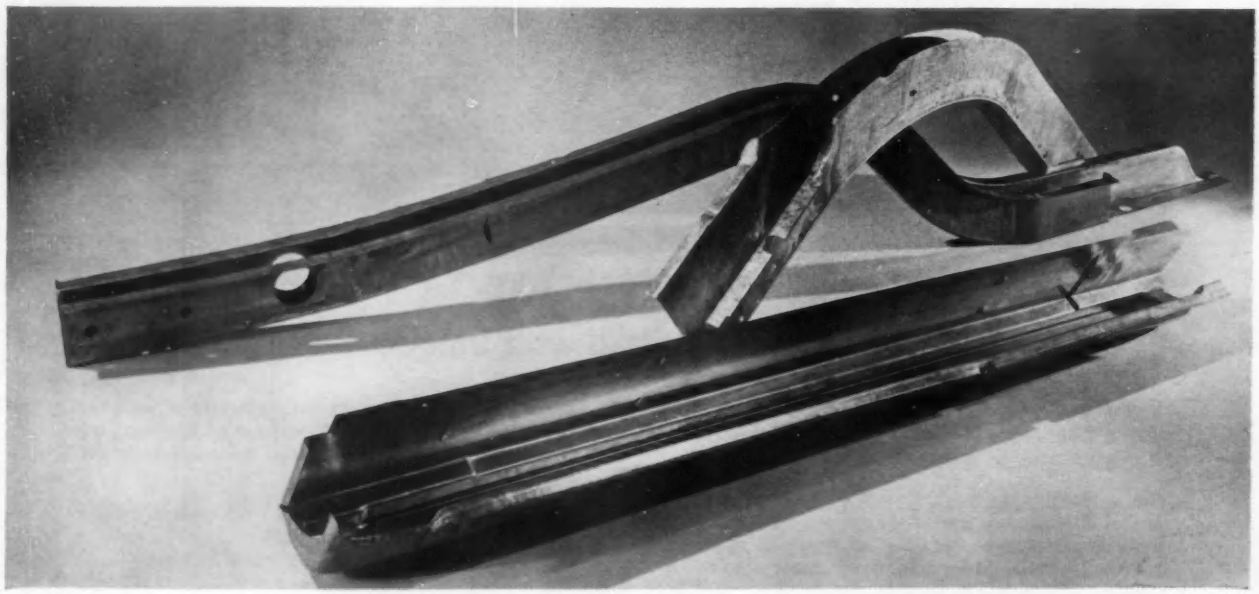
ball bearings

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

New steels are born at Armco

CAN YOU MATCH THIS WITH

Zinc Coating on Armco ZINCGRIP from rust at average cost of 2⅓¢



Galvanized Steel

Use this label to identify your products made of strong, durable steel

PAINTING OR PLATING?

gives parts protection per square foot

Check these typical cost comparisons

Steel thickness	Cost of* ZINCGRIP Coating ¢/sq. ft. of sheet	Typical** Cost of Painting ¢/sq. ft. of sheet	Savings with ZINCGRIP ¢/sq. ft.
.025	1.83¢	3.25¢	1.42¢
.050	2.72	3.25	.53
.075	2.51	3.25	.74
Average	2.35¢	3.25¢	.90¢

*Coated both sides **Painted both sides

Computations based on coils 24" to 36" wide. ZINCGRIP coating costs are additional costs beyond price of cold-rolled steel. Paint costs are figured on typical dip-painting or flow-coating methods and include costs of metal preparation, paint, labor and overhead of painting operations. Some paint costs may be lower than these; many are higher.

A manufacturer of small automotive stampings saved 2.8¢ per piece by using Armco ZINCGRIP® and eliminating cadmium plating. Another manufacturer reported savings of $6.34 per ton by using ZINCGRIP for bus floors in place of hot-rolled steel, bonderized and prime-coat painted. Besides initial savings, ZINCGRIP provides a two-side full-weight coating of zinc for superior protection against corrosion. It's exceptionally workable, too. Base metal and zinc coating hold up under severe fabrication.

Founder of versatile "family"

ZINCGRIP was first in a series of specialized Armco hot-dip zinc-coated steels. They're produced with normal spangles or spangle-free, differentially coated for painting on one side, or if specified, mill-treated for immediate painting after fabrication.

Let us work with you in comparing costs for painted or plated parts with costs for the same parts made of Armco ZINCGRIP — or one of its zinc-coated "family."

Just fill in and mail the coupon.

Armco Division
Armco Steel Corporation
2491 Curtis Street, Middletown, Ohio

☐ Send me your bulletin, **Economy of Armco ZINCGRIP for Hidden Structural Parts**

☐ Have an Armco representative call

NAME_____ TITLE_____

FIRM_____

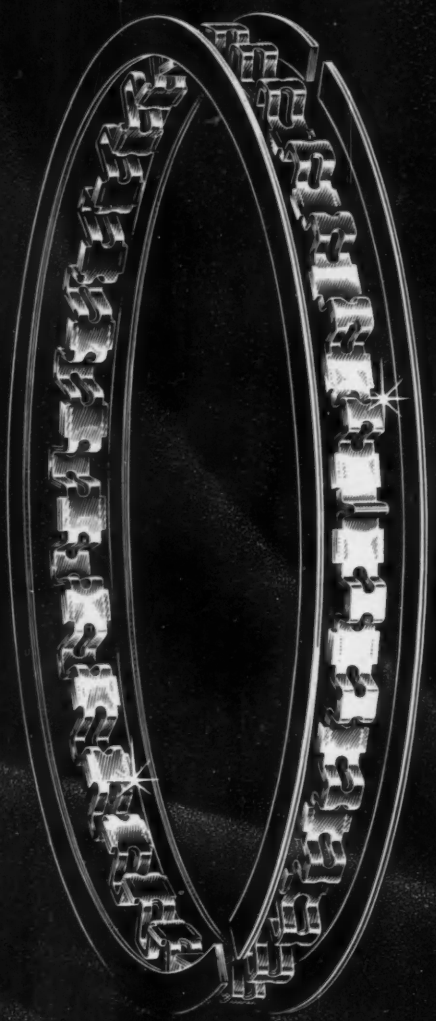
STREET_____

CITY_____ ZONE____ STATE_____

ARMCO

Armco Division

80,000,000 cylinders can't be wrong!



U. S. Pat. No. 2,789,872

Sealed Power Stainless Steel Oil Rings

CONTROL OIL BETTER . . . GIVE LASTING ECONOMY!

That's why manufacturers who build more than 85% of all U. S. cars specify Sealed Power-designed Stainless Steel oil rings for their new cars—and for service.

More than 80,000,000 Stainless Steel oil rings have been factory installed.

Sealed Power's patented, *proven* design, combined with superior Stainless Steel, side seals, licks the oil control problem in high compression, high vacuum engines.

Stainless Steel retains tension at high operating temperatures. Stainless Steel resists pitting and etching of gases, greatly reduces carbon build-up so that return oil vents remain open permitting the free return of oil to the crankcase.

Unique end-abutment design of Sealed Power Stainless Steel oil rings ends groove depth problems; rings have proper tension regardless of contact with bottom of groove.

Chrome-plated side rails seat instantly. And installation's a snap!

Progress through profits

Sealed Power Preferred Performance

PISTONS • PISTON RINGS • SLEEVES • SLEEVE ASSEMBLIES • PRECISION CASTINGS • SEALING RINGS FOR ALL APPLICATIONS

SEALED POWER CORPORATION, MUSKEGON, MICHIGAN • ST. JOHNS, MICHIGAN • ROCHESTER, INDIANA • STRATFORD, ONTARIO • DETROIT OFFICE • 17600 WEST 8 MILE ROAD, PHONE 357-4141

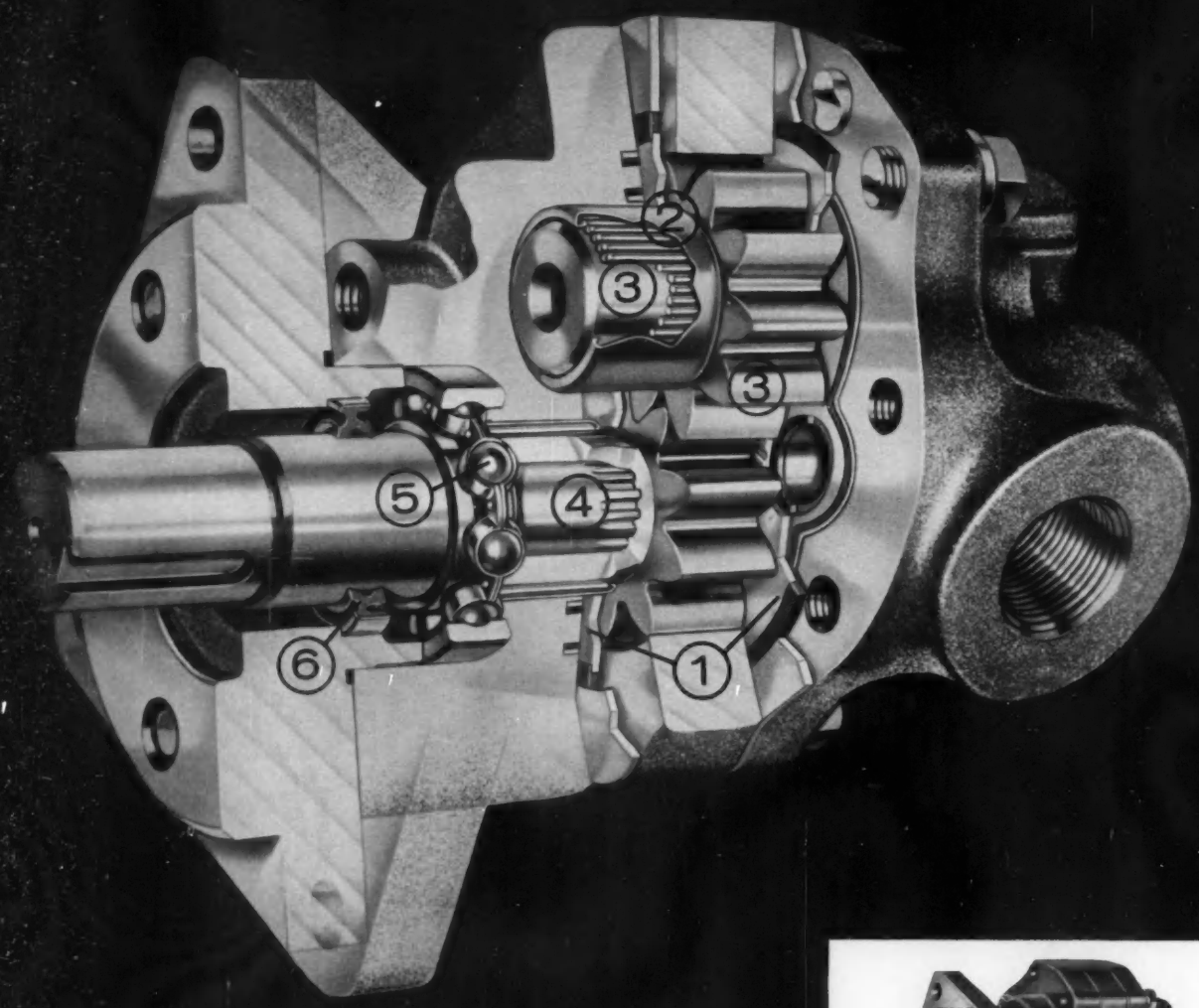
Choosing *exactly* the right bearing can mean a vital difference in performance, cost and product life. That's why it pays to call Torrington first.

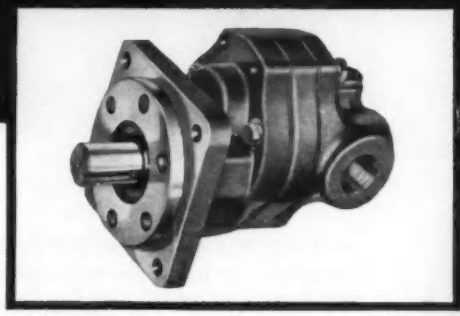
Torrington makes *every* basic type of anti-friction bearing . . . can advise you *impartially* on the best bearing for *your* application. Needle, roller or ball . . . you won't find finer bearings than Torrington. Specify with confidence. If you have a bearing problem, call or write us today. Send for catalog information.

1. Drawn Cup Needle Bearing. Maximum radial capacity in minimum cross section. Easily positioned by press fit. **2. Drawn Cup Roller Bearing.** Ample lubricant storage for smooth starting, cool running, extra-long service life. **3. Heavy Duty Roller Bearing.** Top bearing efficiency and long life under toughest shock conditions. **4. Roller Thrust Bearing.** Precision built for outstanding performance. Large Controlled Contour rollers for maximum capacity. **5. Self-Aligning Ball Bushing.** Low cost unit for top performance in rugged applications. **6. Spherical Roller Bearing Pillow Block.** High radial and thrust capacity. Fast, easy installation. Grease or oil-bath lubrication. **7. Needle Thrust Bearing.** Unequalled capacity for size and weight. Runs directly on hardened ground surfaces, or on standard thrust races. **8. Cam Follower.** Exceptional combination of high capacity, maximum toughness, dependable performance under shock loads. **9. Spherical Roller Bearing.** Precision engineered for maximum efficiency, optimum service life. Self-aligning.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Connecticut • South Bend 21, Indiana





Here's how **WEBSTER** *puts new efficiency in hydraulic power*

We cut this new JE series pump in half to show you why Webster design tops competition in overall efficiency. Specifically, the JE saves horsepower, slashes operating costs, delivers dependable and trouble-free service.

It's the result of this combination of advanced features.... (1) pressure-balanced wear plates for high volumetric efficiency and to prevent clearance changes due to heat; (2) needle bearings for power-saving, anti-friction operation; (3) one piece gear and bearing journal units to assure minimum deflection and proper alignment on both drive and idler assembly; (4) free-floating internal spline drives to eliminate key failures; (5) thrust bearing on drive shaft to absorb compound driving thrusts; (6) double lip seal on drive shaft for added protection against seal failure and dirt.

The Webster JE series pump is a heavy-duty, big power unit built to meet the needs of the mobile industry. It is trim and compact to fit into tight quarters, attaches with a choice of mountings. Your Webster Electric representative has complete specifications and data — or write direct for engineering detailed sheet HY1-1.

JE SERIES PUMPS

Shaft seal: double lip type
Drive: direct, gear or belt
Capacity: 10 sizes — 5 to 40 gpm
Pressures: to 2000 psi
Operating Speeds: to 2400 rpm
Porting: side (std.) end (opt.)
Mounting: SAE Type A (std.)

OIL HYDRAULICS DIVISION
WEBSTER ELECTRIC
RACINE · WIS

No rattles, no squeaks, no wind noises in this car window.

That's the kind of silence you install with Schlegel woven pile liner.

This thick pile runs uniform through the length of the glass channel. It smothers noises before they start.

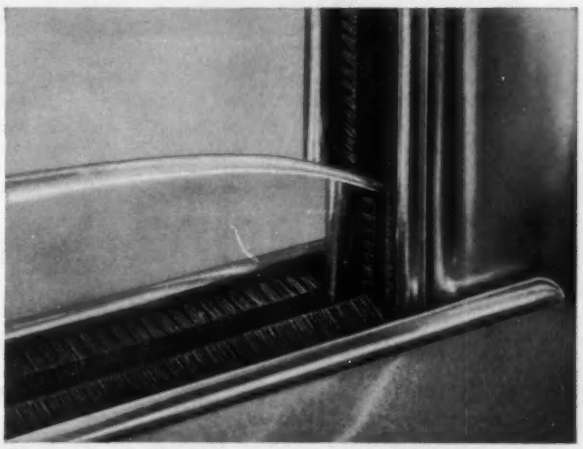
It's a resilient pile. It hugs the surface of the glass tightly—but not so tightly that it restricts window movement.

It's a protective pile. It effectively seals out dust, wind and moisture.

And it's a permanent pile. Each individual strand of pile yarn is interlocked with the woven fabric backing. Thousands of opening and closing actions will not affect this pile. Schlegel pile is a natural seal designed to retain its consistency under all conditions.

Silence? Of course. With proper resilience, density and pile height, a Schlegel woven pile will satisfy the most critical design engineer—but, most of all, dealer and customer satisfaction is assured.

Like to install silence in your automobile windows? Specify Schlegel woven pile in your glass run channels and weatherstripping. They've been used in the quieter cars for decades.



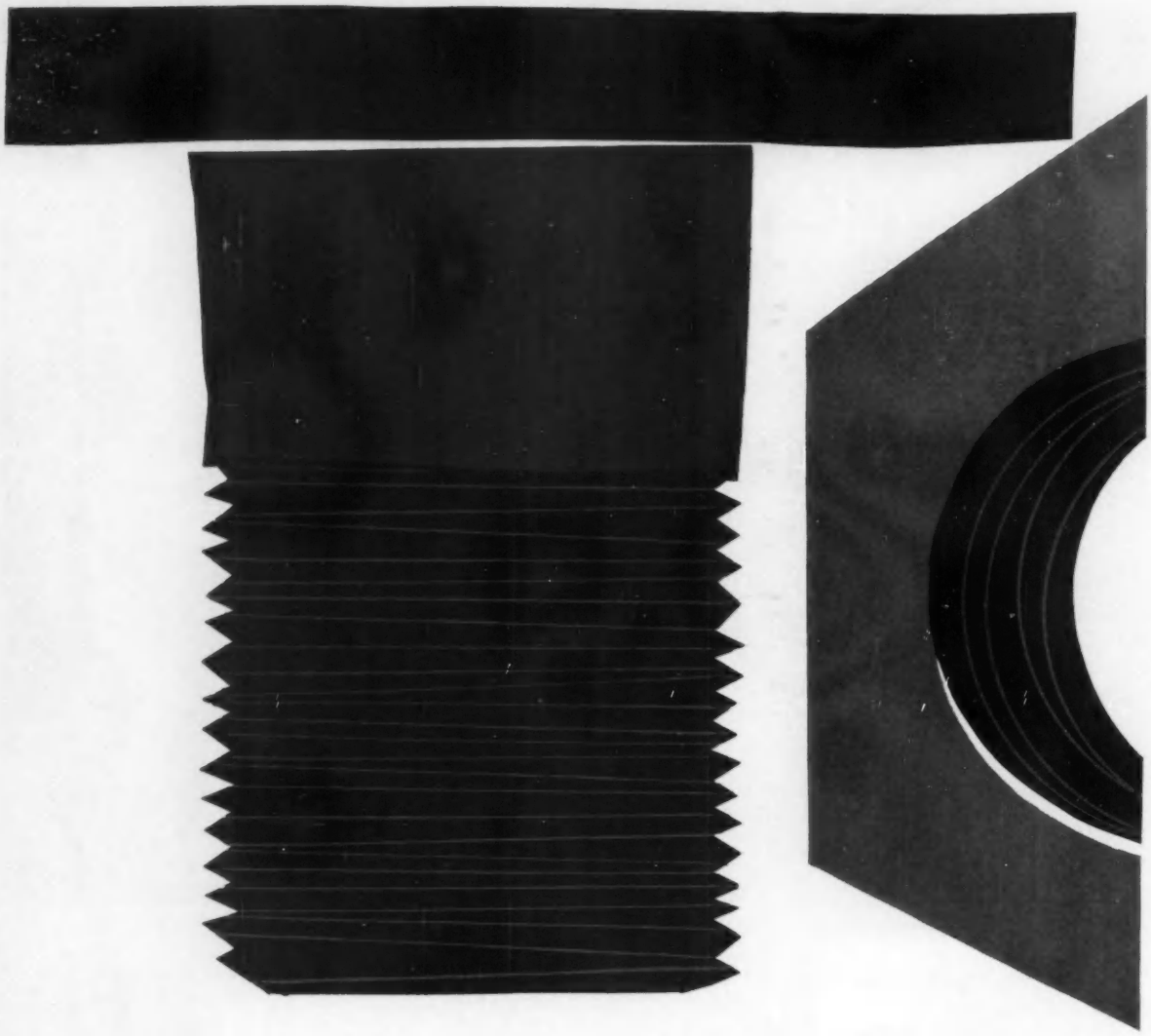
Glass moves friction-free, wet or dry, in this glass run channel with Schlegel woven pile liner.

Schlegel

SERVING THE AUTOMOTIVE INDUSTRY

SCHLEGEL MANUFACTURING COMPANY

1555 Jefferson Rd., Rochester 23, N.Y. In Canada, Oakville, Ont.



imagineering is the bold new look at Screw & Bolt that says "infinite design capability." Imagination, coupled with engineering, has led to endless new product design developments in fasteners and other threaded parts. ■ Need a new design fastener or threaded part where standard shelf items just won't fit? Clip this ad to your letterhead and Screw & Bolt's sales engineers will put *imagineering* to work for you.

VMA 9397

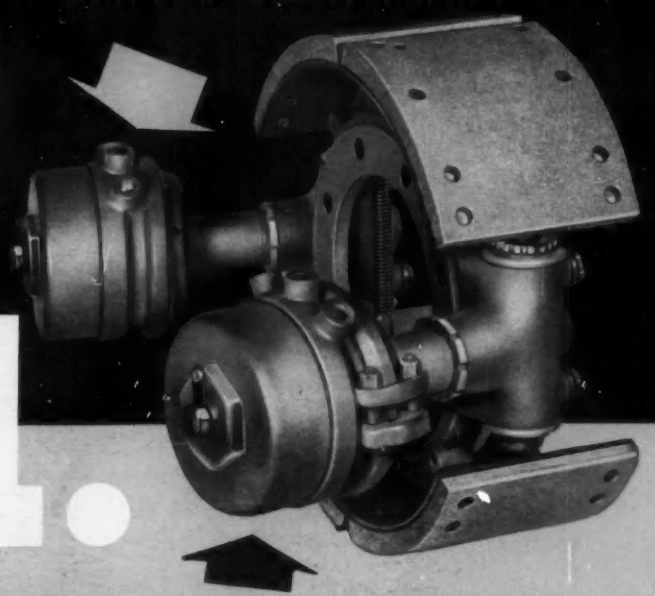
SCREW AND BOLT CORPORATION
OF AMERICA • P.O. BOX 1708, PITTSBURGH 30, PA.
Plants: Pittsburgh, Pa. Gary, Ind. Southington, Conn. Norristown, Pa. • Warehouses: Portland, Ore. Denver, Colo. Atlanta, Ga.

Imagineering... for greater fastener progress

NEW STOPMASTER BRAKE

OFFERS THESE 3 BIG EXTRAS!

ANOTHER ROCKWELL-STANDARD FIRST!



Proven the most advanced brake design in 30 years . . .

Outstanding improvements, such as a new balanced shoe actuation principle and 15" diameter, have made the Stopmaster Brake the industry's most efficient and dependable brake. Now Rockwell-Standard also offers you these three important extras in the Stopmaster:

1.

"Fail-Safe" Units . . . now available for air actuated Stopmaster Brakes.

- Prevents runaway vehicles due to loss of air, when in operation or parked.
- Positive mechanical operation . . . can be installed to operate from dash control valve or automatically, or both ways if desired.
- Lightweight and compact . . . no installation problems, no cables or special brackets required.
- Provides mechanical parking brake . . . eliminates need for prop-shaft brake.
- Brakes easily released . . . without air pressure.

2

Automatic Brake Adjustment . . . available on all Stopmaster Brake sizes for trucks, trailers, and off-highway vehicles.

- Eliminates periodic manual adjustment.
- Cuts expensive maintenance costs.
- Brake maintains proper adjustment during entire lining life.
- Safer operation at all times.

3

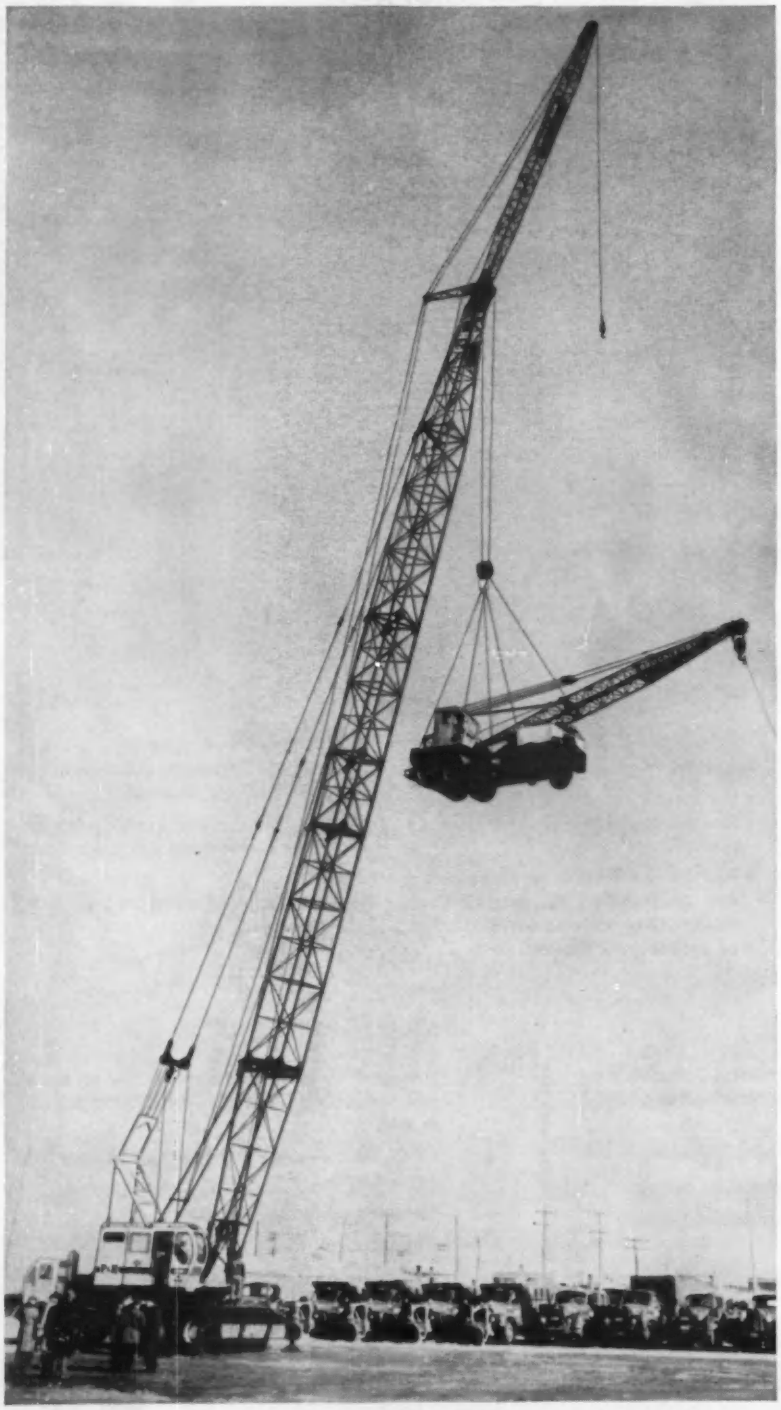
Lubrication Eliminated. All actuating parts are sealed in lubricant. Standard on all models.

- Prevents oil-soaked linings due to over lubricating.
- Moving parts last longer.
- Reduces friction.
- Completely sealed unit reduces effect of elements.

Another Product of... **ROCKWELL-STANDARD CORPORATION**

Brake Division, Ashtabula, Ohio

Giant truck crane can lift 90 tons ...lifts "little brother" for laughs



Nickel-moly steels give power train strength and toughness

Rolling on twelve huge tires and wielding a 250-foot boom, this bruiser can handle 90-ton loads with ease. Here you see it dangling its 31,000 pound "little brother" at a demonstration given by the manufacturer, Harnischfeger Corporation of Milwaukee.

At the planning stage, their engineers anticipated great operating stresses, designed critical power-train components around the properties of nickel-molybdenum alloy carburizing steels.

AISI 4820 (3½% nickel) is specified for the most heavily stressed transmission gears and auxiliary transmission gears. These components are carburized and hardened to handle the highest compressive loads, and at the same time develop high core strength and toughness to resist severe torsion and impact.

AISI 4620 (1.8% nickel) is used for a variety of gears, shafts, and pinions which encounter all but the most severe stresses.

When you design, order, or build construction machinery, count on nickel-moly steels to deliver the specific combinations of properties that give heavy equipment built-in strength and toughness.

You'll find materials-engineering data on 11 types of heavy construction equipment in a new 76-page Inco booklet. For a free copy, request "A-265."

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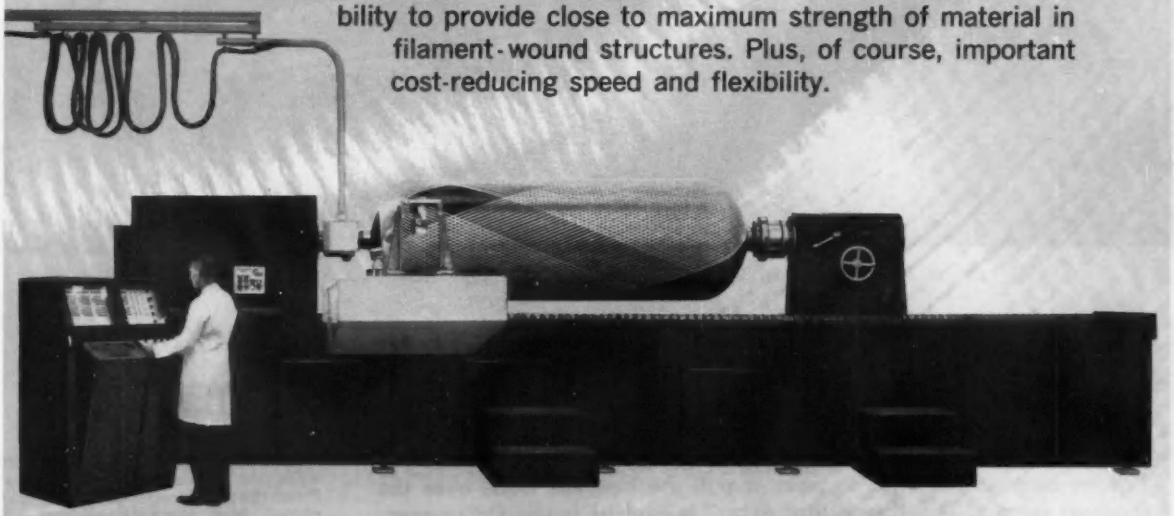
The industry's first tape-controlled, continuous-path filament winding machine is in full production now. Designed and built by Rohr, it wraps glass fibre filaments with amazing precision to form lightweight structures of great strength, such as the rocket motor case shown below. It is capable of winding parts up to 25 feet in length and 8 feet in diameter—and has the ability to wind an infinite variety of patterns, including a continuous filament pattern for multiple-nozzle motor cases. Actually, the wrapping of different pressure vessels is as simple as changing the tape. This advanced machine demonstrates Rohr's unique skill in designing and building highly specialized manufacturing equipment... plus knowledge gained from years of programming and production of three-dimensional parts by numerical control. The ability to produce precision-wound products on this new filament winding machine demonstrates the breadth of our research into plastics and adhesives and the depth of our experience in collapsible mandrel manufacture. Because it achieves such precise and uniform positioning of filaments, this Rohr machine now offers the industry the capability to provide close to maximum strength of material in filament-wound structures. Plus, of course, important cost-reducing speed and flexibility.



ROHR NUMERICALLY CONTROLLED FILAMENT WINDING MACHINE

For information on this and other Rohr production techniques please write Mr. A. R. Campbell, Sales Manager, Dept. 59, Rohr Aircraft Corp., Chula Vista, Calif.

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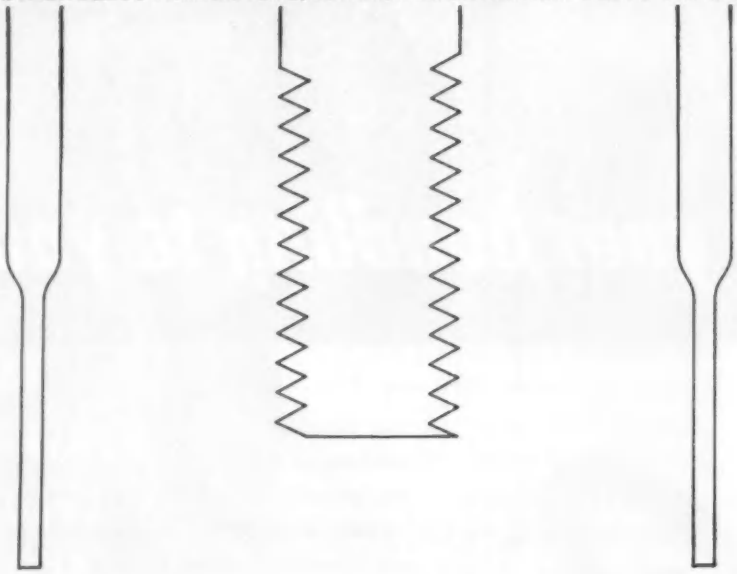

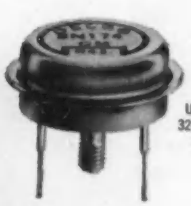

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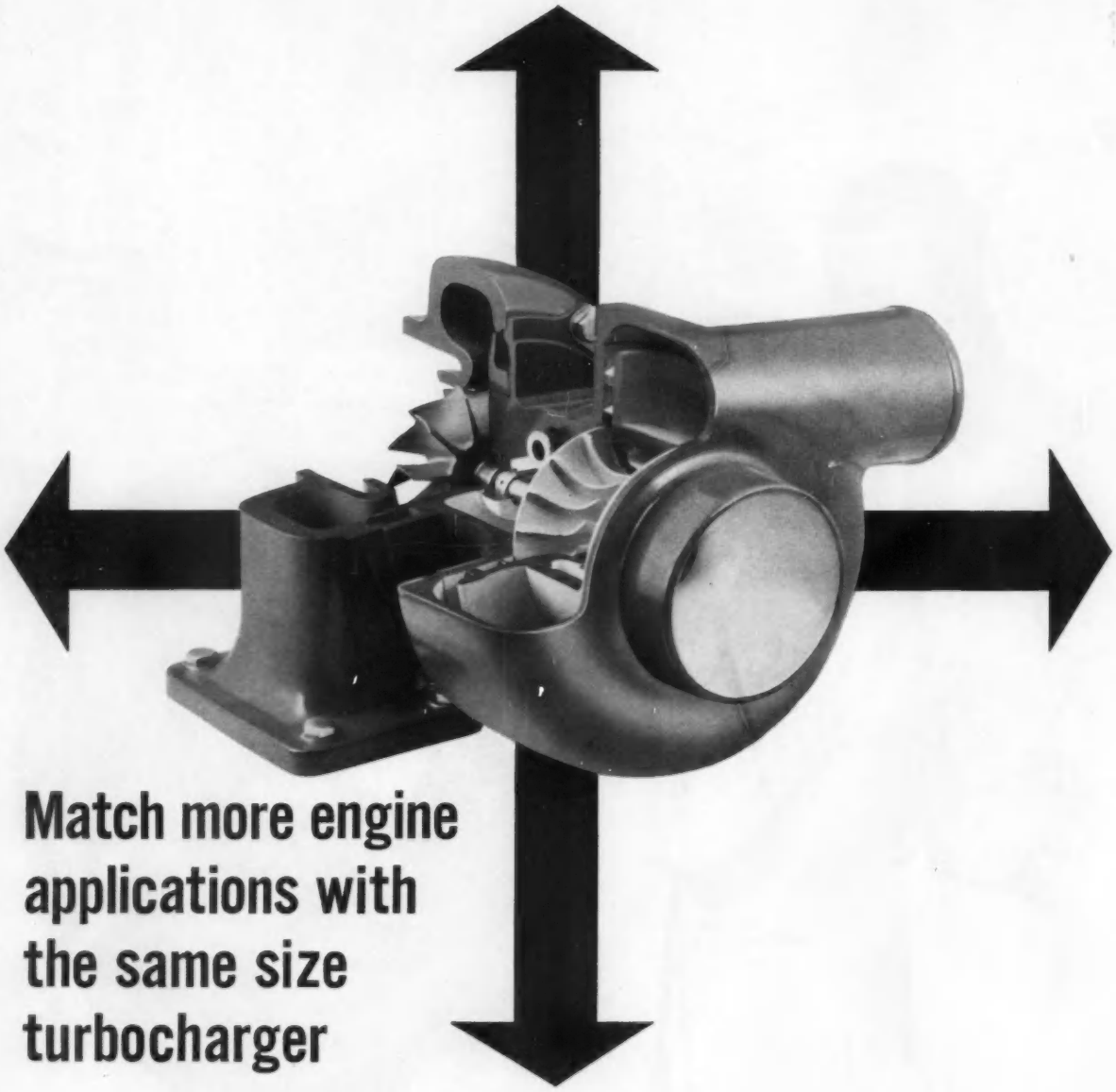

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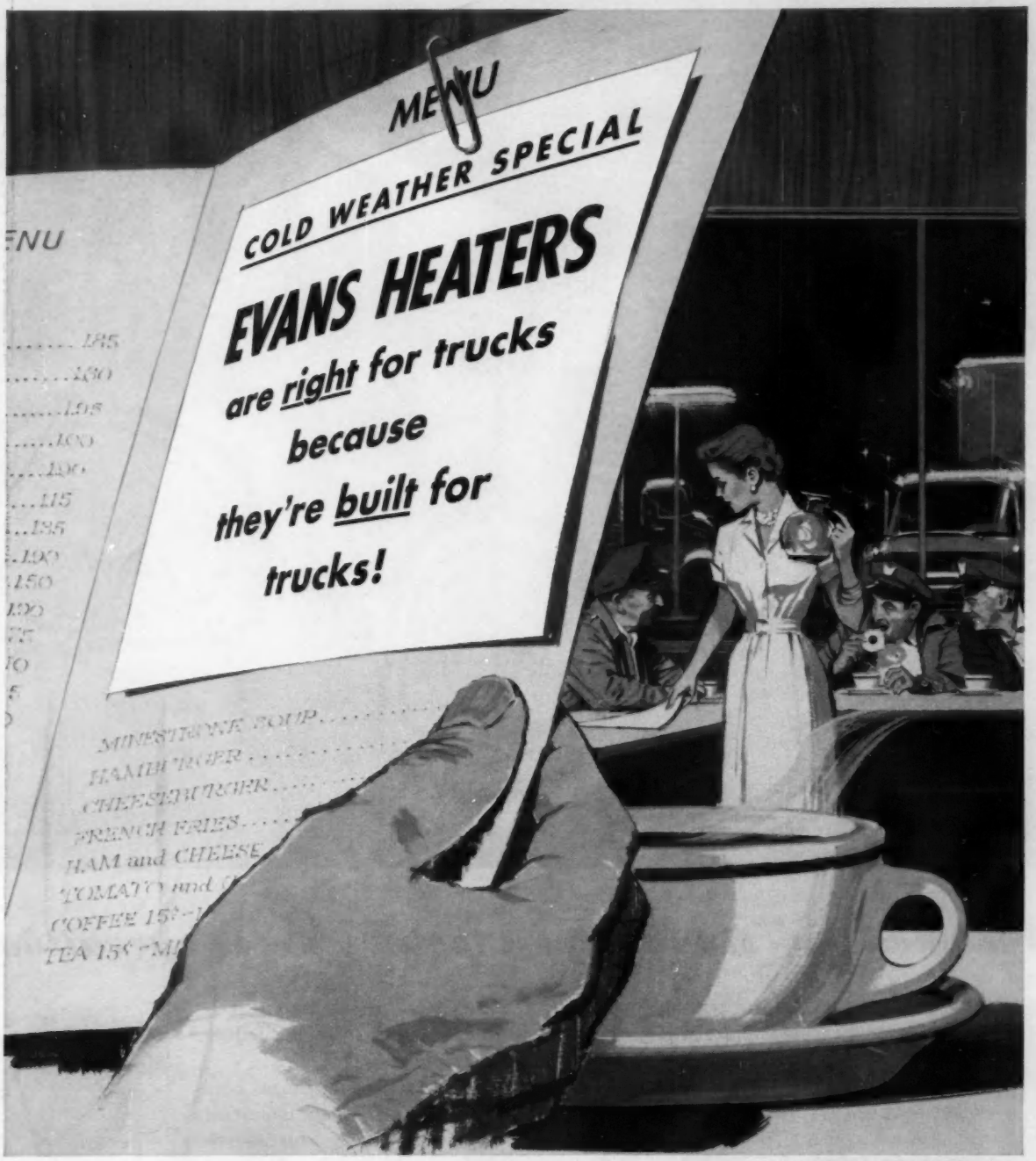

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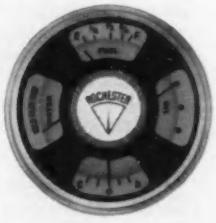

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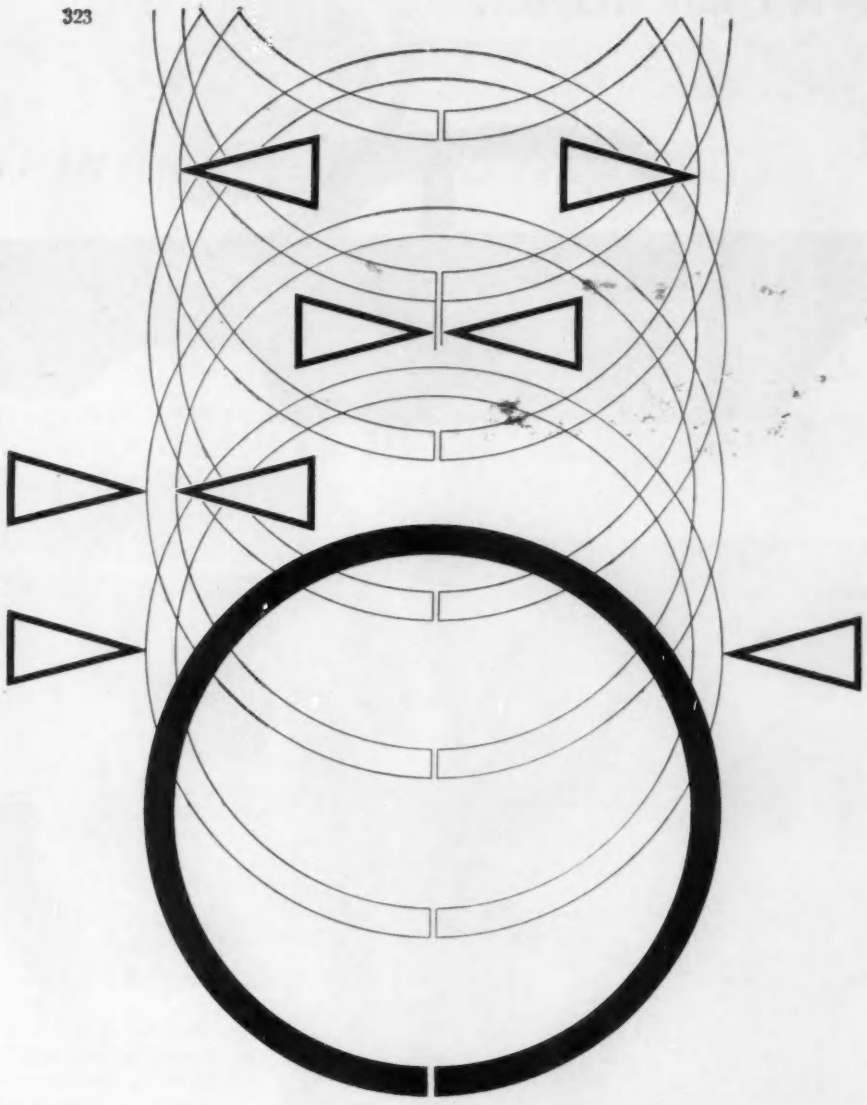

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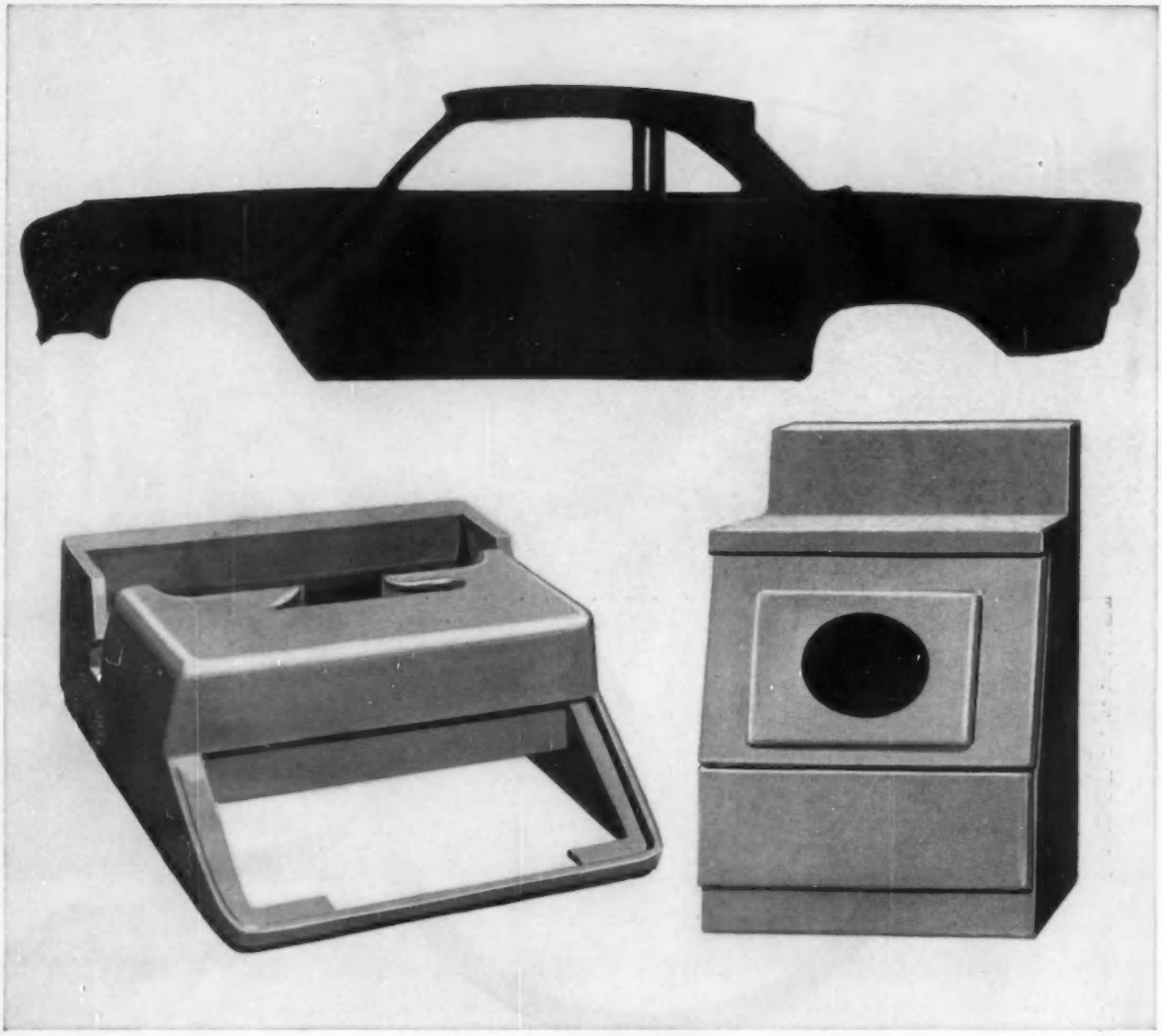

BUTON® Resins produce tough, low-cost primers!

Buton resins contribute to low-cost, long-lasting protective metal primers. Several inherent properties make them a natural choice for numerous metal priming applications. Buton resins possess excellent hardness, toughness, and flexibility . . . combined with outstanding resistance to such corrosive materials as: detergents, salt spray, boiling water, plus many acids and alkalis.

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One in a series of technical reports by Bower

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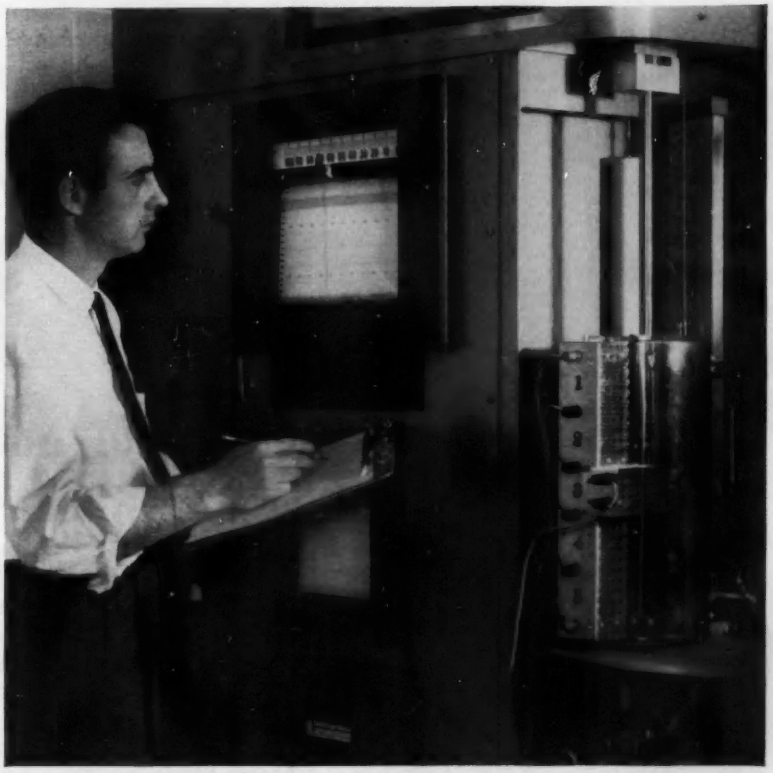
TESTING PUTS THE HEAT ON—HELPS BEARINGS BEHAVE IN EXTREME ENVIRONMENTS

In industry today, bearing operating conditions are becoming increasingly severe. To conquer difficult environments, heat, corrosion and oxidation, Bower conducts exhaustive research to achieve improved bearing performance. One important area of Bower research, for example, is the development of special alloys to withstand extreme heat. To do this, Bower researchers use special heating apparatus to study hardness, strength and other characteristics of alloys at temperatures in excess of 1000°F.



Bower engineers study how alloys stretch as temperatures rise in excess of 1000°F., to perfect bearings that can take it.

One of the devices Bower utilizes to assure bearing precision at high temperatures is a creep tester. Bower engineers use it to load a test bar to a predetermined stress level, then, with the assistance of a special heating unit, find out precisely how much the bar stretches as temperatures are elevated to a thousand degrees F., and beyond.

With this type of data and the help of other Bower precision research equipment, engineers can determine alloys that best withstand torrid temperatures. They can also effectively mate thermal expansion characteristics of the various alloys used in roller bearing components and in shafts and housings as well. As a result of this mating, Bower creates bearings that maintain precision in the required temperature ranges and ensures bearings that provide long life, heavy load capacity and high-speed operation.

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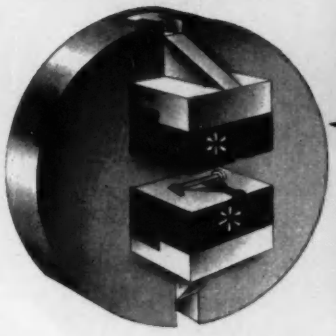

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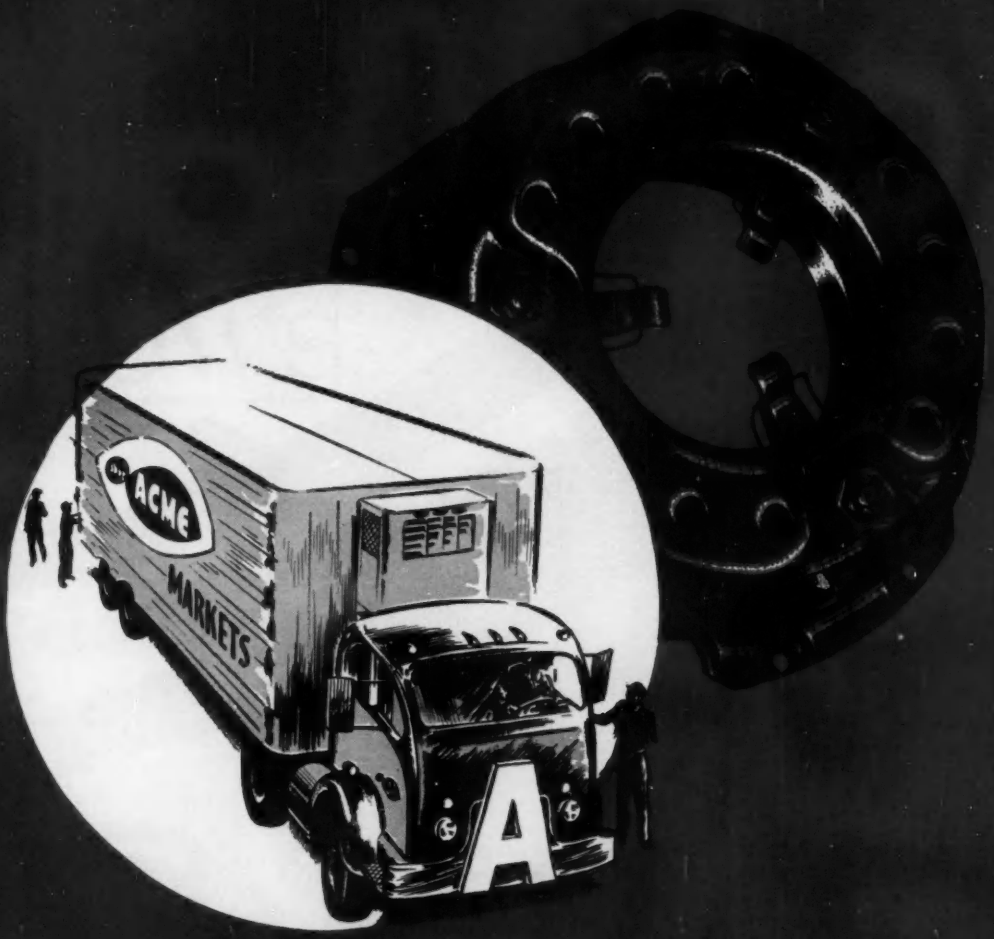

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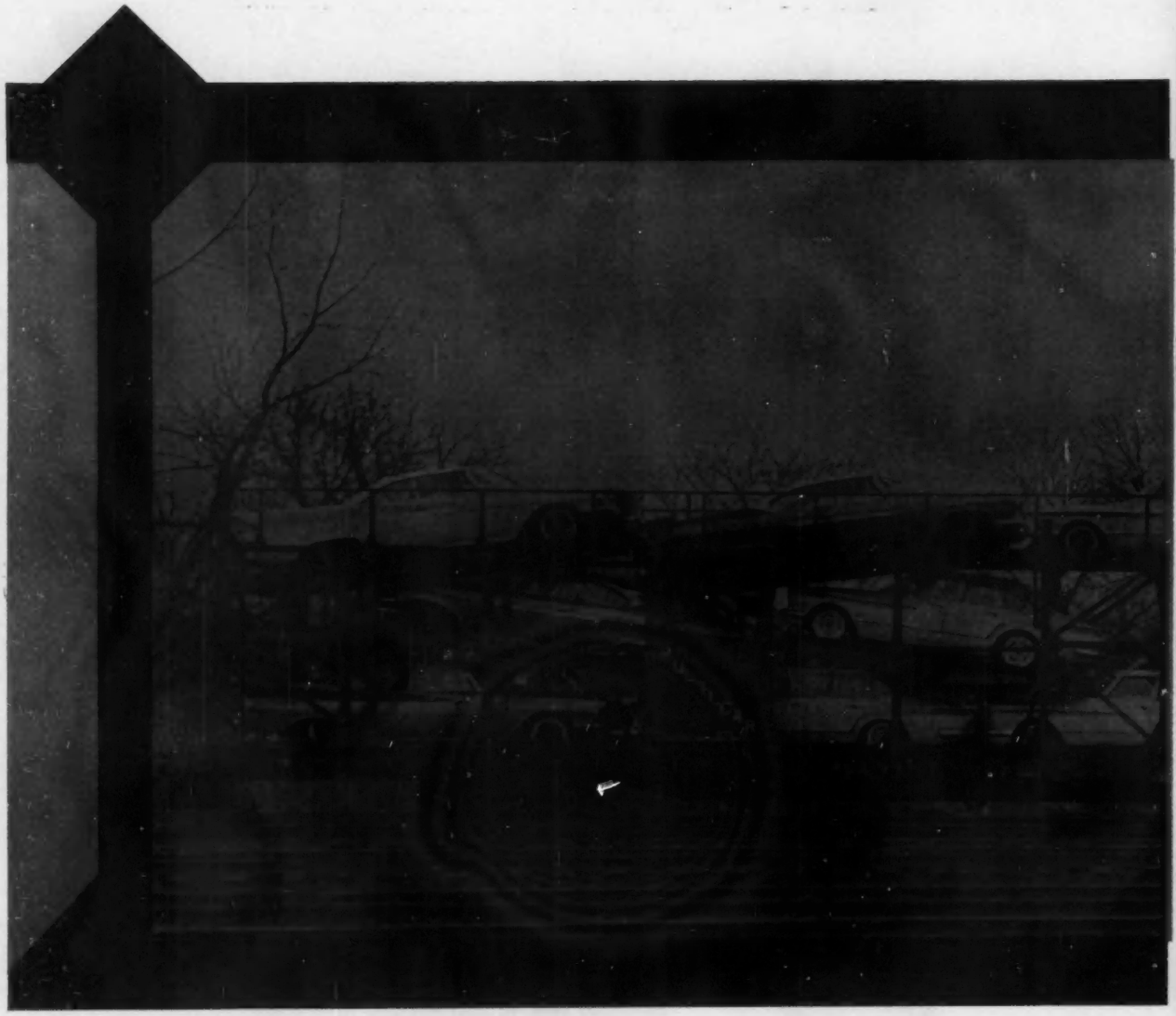

GLX-W COLUMBIUM-TREATED CARBON STEEL CUTS DEAD WEIGHT 10% IN NEW

VERSATILITY...
That's the Beauty of Steel

Bringing important new economies to rail shipment of automobiles, this new tri-level auto carrier holds twelve standard cars or mixed loads of 14 standards and compacts. Capacity is increased up to 75%. A unique system of hydraulically positioning the vehicles on three levels gives a clearance of only 16 feet 8 inches, permits use in areas formerly limited to bi-level unit operation because of clearance requirements. ◆ Key feature of the Multi-Car Carrier is the movable decks on which the cars ride. Made of GLX-W columbium-treated steel, the decks are raised and lowered by built-in hydraulic lifts, actuated by a portable power unit. Here light weight was essential, in order to reduce the operating power requirements. Yet great strength was necessary, too, to support the payload. Finally, design of the decks called for eight bends in each section. So formability was also a must. ◆ GLX-W met and exceeded all these requirements. It gives 50-100% greater strength than mild carbon steel, so builder Whitehead and Kales could get the required strength with less weight. Deck operating units need less power,

Great Lakes Steel is a Division of

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TRI-LEVEL AUTO CARRIER

and total weight is reduced approximately 5,000 pounds or 10%. Production is more economical, too, because the ductility and formability of GLX-W permits four of the bends in the deck to be performed in one press operation. ➔ The GLX-W series of high-strength steels consists of fine-grained, semi-killed mild carbon steels, treated with varying amounts of columbium. The high strength of GLX-W permits designers to reduce the amount of steel and effect considerable cost savings when replacing mild carbon steel. GLX-W steels have a low carbon content and are readily weldable and formable. GLX-W steels are available at four minimum yield strength levels: 45,000, 50,000, 55,000 and 60,000 p.s.i. and in sheets, plates and bars. For complete technical information, write Great Lakes Steel Corporation, Product Development, Dept. SAE-9, P. O. Box 7310, Detroit 2, Michigan.

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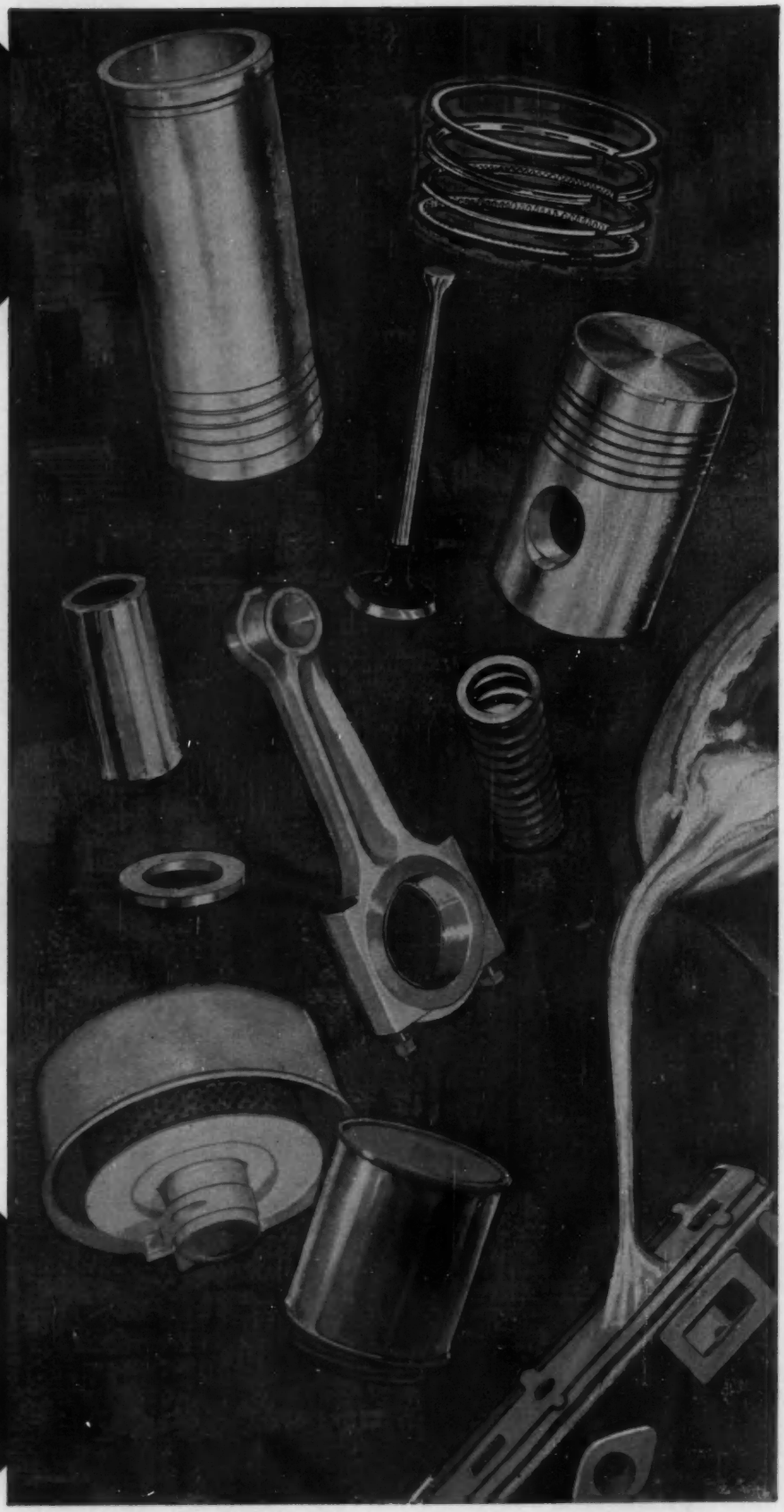

GN

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In creating its new Engine Parts Division, Gould-National combined under one corporate roof the brands, products, services and facilities of these wholly-owned subsidiaries:

Wilkening Manufacturing Co., Philadelphia, manufacturers of Pedrick® piston rings and castings.

White Machine Works, Eau Claire, Wisconsin, manufacturers of Superior-Arrowhead cylinder sleeves, sleeve assemblies, pistons, piston pins, Burd piston rings, valves and valve train parts, foreign car engine parts and filters.

Gillett & Eaton, Lake City, Minnesota, piston and casting specialists of cast iron, aluminum alloy, Vanasil® aluminum alloy pistons and specialized engine parts.

Arrow Head Steel Products, Howell, Michigan, manufacturers of aluminum pistons, connecting rods and other castings.

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Product improvement will result from the formation of a special team in the Gould-National Engineering and Research staff. It is the Gould-National way of assuring continuing top quality and improved product performance.

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This is the Gould-National Engine Parts Division—the nation's newest parts manufacturing group with over two centuries of combined experience.

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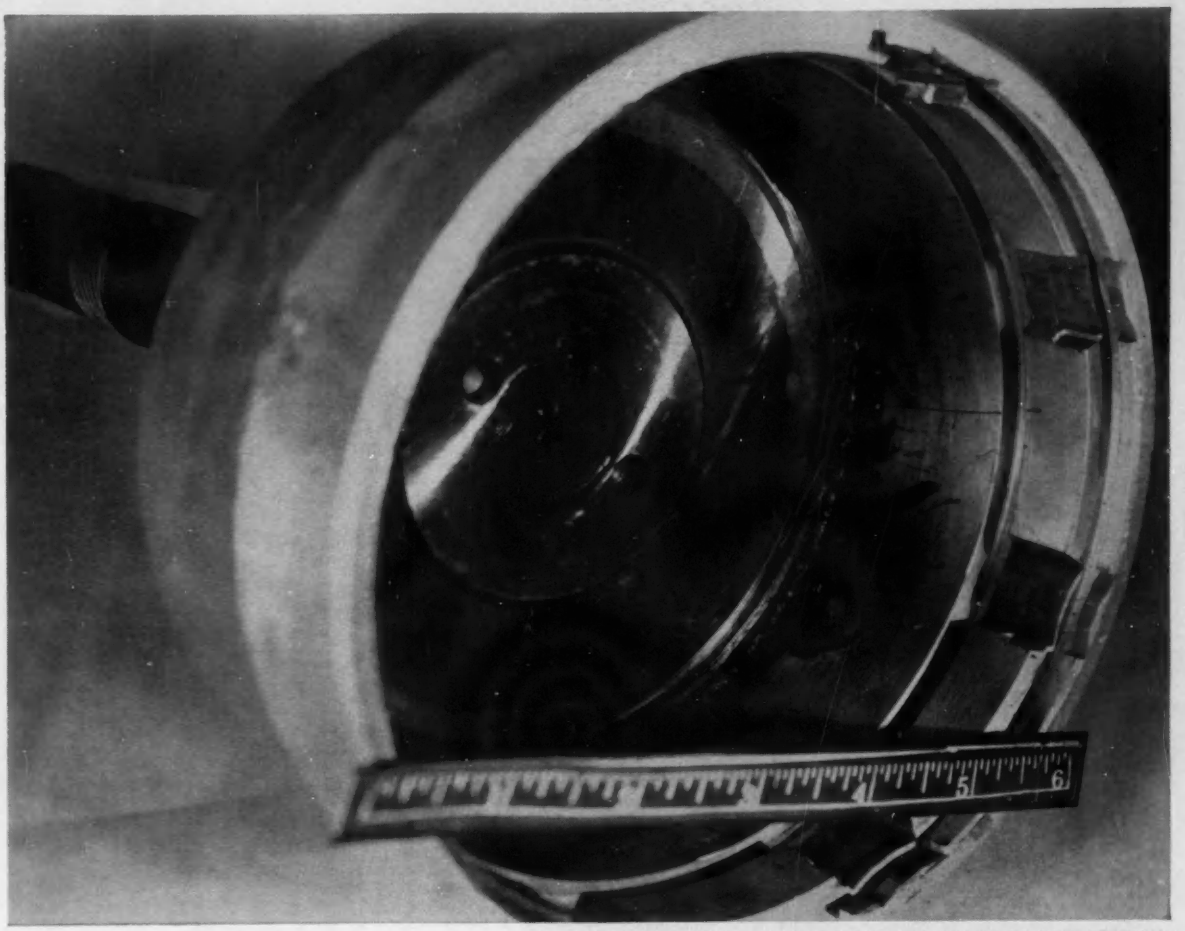

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This is the housing of an automotive torque converter. It's joined to the output shaft by a thin film of thermoset cement.

The converter has just undergone torsional tests that wrecked its mechanical parts—with no effect whatever on the metal-to-metal bond. This bonding job is an achievement of Cycleweld Chemical Products Division of Chrysler Corporation.

A similar cement, made of nitrile rubber and Durez® phenolic resin, cut the cost of assembling an all-aluminum truck tailgate by eliminating 211 rivets and 42 welds.

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- attaching metal trim without drilling holes.
- easy-to-cast aluminum engine heads and intake manifolds, made in *two* sections bonded together with a leakproof, heatproof seal.

If you have a tougher-than-usual bonding problem—or expect to have one—now's the time to see what a rubber-phenolic adhesive can do for you. We'll be glad to put you in touch with people who make such adhesives.

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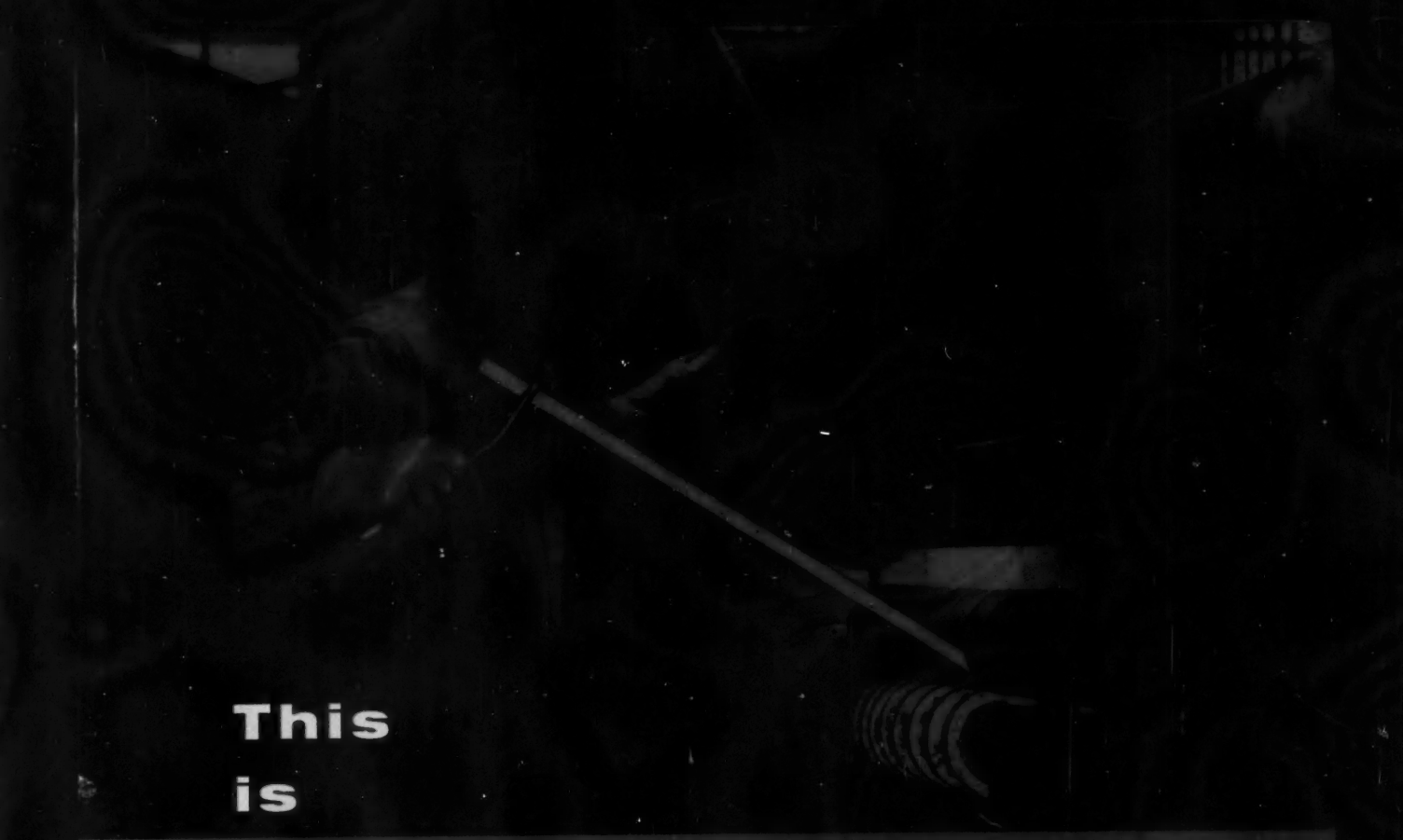

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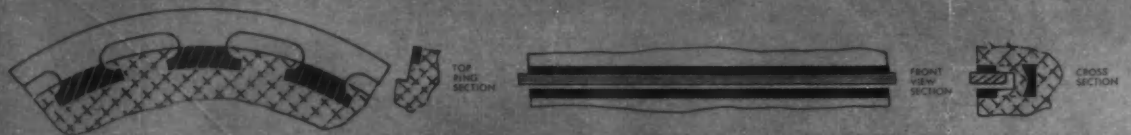
. . . CAST ANCHORED TOP RING SECTION

ENGINEERING ADVANTAGES OF ZOLLNER "CONTINUOUS PERMA-GROOVE"



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2. Dovetailed edges keep insert securely in place
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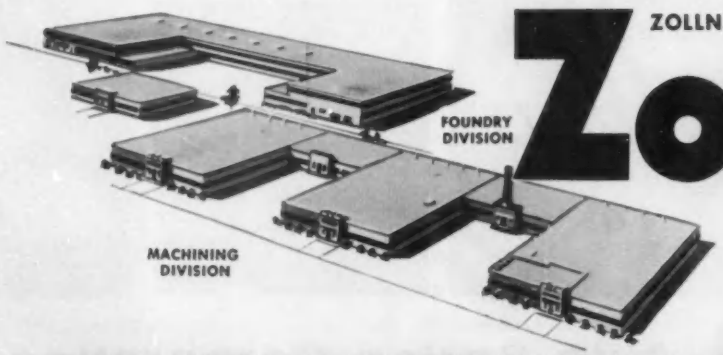
4. 40% aluminum bearing area exposed for heat conductivity and cool operation
5. Light in weight



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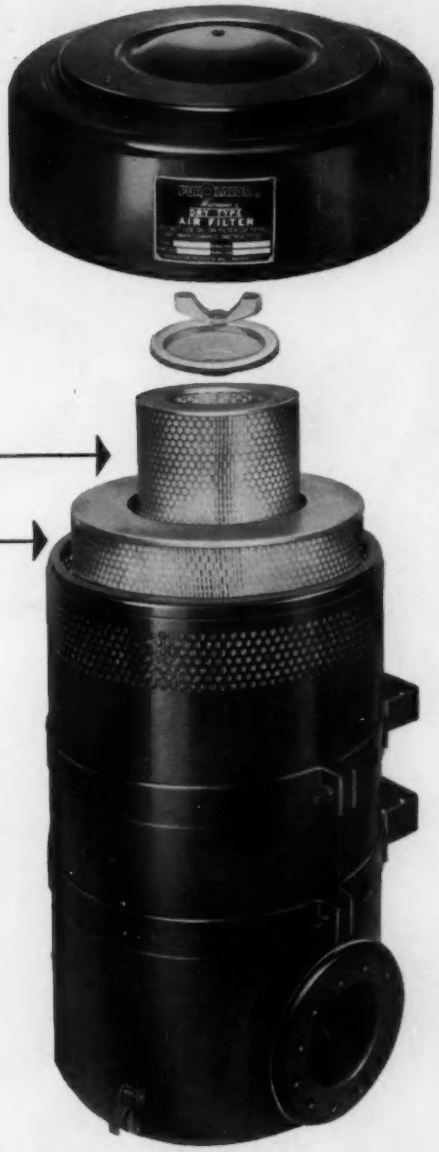

an element here

and an element here

assures 99.98% filtration efficiency even when 1 element is out of operation

IT'S THE NEW PUROLATOR TWO-STAGE FILTER

Simplicity of design makes the first cost of Purolator's new dry-type two-stage filter as low as any two-stage filter on the market. Each element filters independently, and together they dustproof your engine as no other filter can . . . 99.98% efficient.

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For more information write to Purolator Products, Inc., Department 3896, Rahway, New Jersey.

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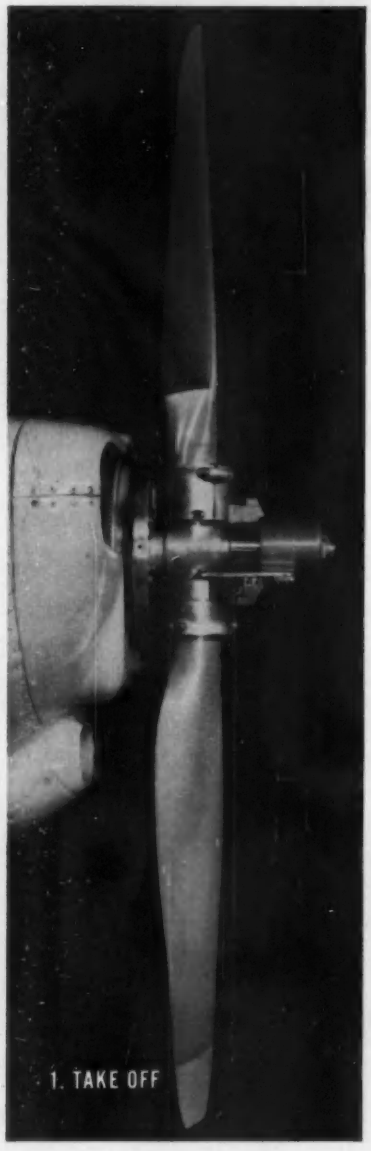

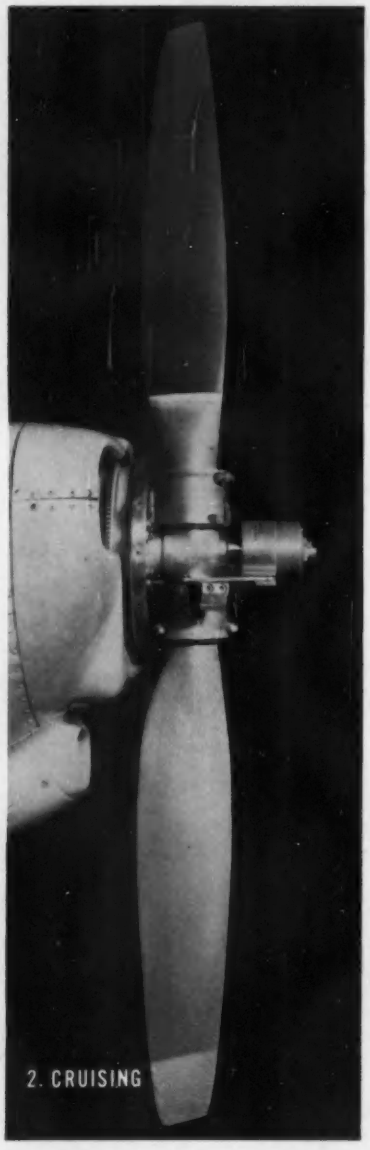

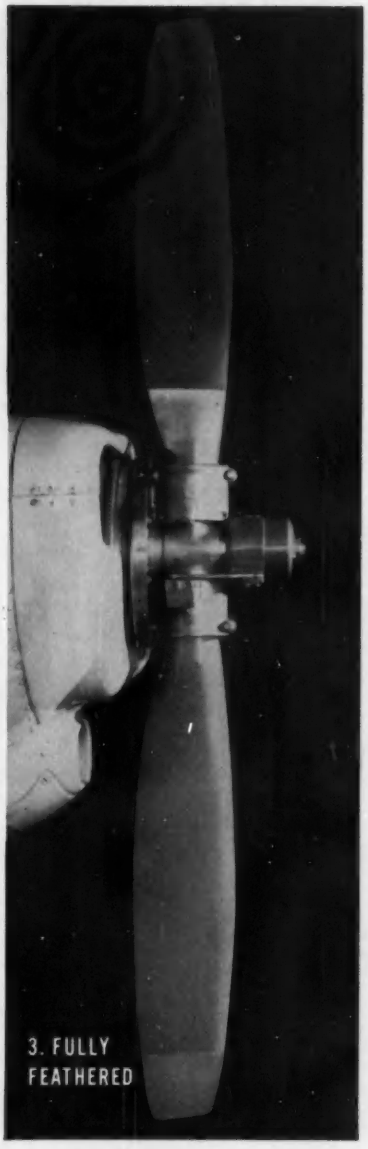

from Hartzell and Timken® steel

To help make executive and private aircraft as "all-weather" as the airlines, Hartzell Propeller Company designed a constant-speed propeller with full feathering and reversible pitch. Short field landings are no problem. Executives can land at a more convenient airport in many cities.

The resemblance to the big transports doesn't stop there. To get the right aircraft quality steel for the propeller hubs, Hartzell engineers came to the Timken Company. Timken® fine alloy seamless steel tubing is known for its cleanliness. And the metallurgists who make it are known for coming up with the best solution to tubing problems. Timken 4140 steel tubing of aircraft quality is cleaner. The propeller hubs can be made light yet strong. And Timken steel tubing cuts rejections because of its uniform response to heat treating. Every part is up to specification. Due to this consistent performance, Hartzell now specifies Timken quality steel for their forgings.

Timken Company metallurgists have been finding solutions to tough steel problems for over forty years. They're specialists in specifying the right mechanical tubing to keep costs *and* rejects down. If you have a steel problem, why not call on the Timken Company? Our experts will be glad to work with your engineers and designers. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

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